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THE

Religious Philoſopher:

Or, the Right USE of

Contemplating the Works of the CREATOR:

I. In the wonderful Structure of Animal Bodies, and in particular, MAN.

II. In the no leſs wonderful and wiſe Formation of the ELEMENTS, and their various Effects upon Animal and Vegetable Bodies. And,

III. In the moſt amazing Structure of the HEAVENS, with all its Furniture;

DESIGNED

For the Conviction of ATHEISTS *and* INFIDELS.

The THIRD and Laſt VOLUME.

Throughout which, all the late DISCOVERIES in *Anatomy*, *Philoſophy*, and *Aſtronomy*, together with the various Experiments made uſe of to illuſtrate the ſame, are moſt copiouſly handled by that Learned *Mathematician*, Dr. *NIEUWENTYT*.

Tranſlated from the Original,

By JOHN CHAMBERLAYNE, *Eſq*; *F. R. S.*

Adorn'd with CUTS.

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THE CONTENTS OF THE THIRD and Laſt VOLUME.

CONTEMPLATION XXIV, *p.* 735.

Of the Viſible Heavens.

Sect. I. *Tranſition to the World in general, and to the Heavenly Bodies in particular.*
Sect. II. *Convictions from the View or Sight thereof.*
Sect. III. *The Sun proved to be bigger than the Earth, by the Eclipſes.*
Sect. IV. *The Sun's Magnitude proved from Aſtronomy.*
Sect. V. *It may be ſhewn with Certainty ſufficient, that the Sun is above a hundred thouſand times bigger than the Earth.*
Sect. VI. *Convictions from the foregoing Obſervations.*
Sect. VII. *The Sun's Diſtance from the Earth.*
Sect. VIII. *Convictions from the foregoing Obſervations.*
Sect. IX. *The Earth for Conveniency ſake ſuppoſed to ſtand ſtill.*

Sect. X. *The Sun's Diurnal Motion.*
Sect. XI. *The Sun's Annual Motion, Declenſion, and the Seaſon's of the Year.*
Sect. XII. *The great Uſe of the aforementioned Motions.*
Sect. XIII. *Convictions from what is ſaid above.*
Sect. XIV, and XV. *The Morning and Evening Twilight.*
Sect. XVI. *The Weakneſs of our Conceptions.*
Sect. XVII. *How much Time is required for a Cannon-Bullet to paſs from the Earth to the Sun.*
Sect. XVIII. *How much Time is required for a Ship, or any living Creature that can run 50 Miles in a Day and a Night, to paſs from the Earth to the Sun: And Convictions from thence.*
Sect. XIX. *The Velocity or Swiftneſs of Light.*
Sect. XX. *An Experiment to prove, that Light moves and comes from the Sun.*
Sect. XXI. *What would be the Conſequence, if the Rays of Light proceeding from the Sun ſhould become a Solid Body, and the Parts thereof adhere to each other.*
Sect. XXII. *Convictions from thence.*
Sect. XXIII. *Light moves in ſtrait Lines.*
Sect. XXIV. *Experiments to prove that Fire is produced by Light.*
Sect. XXV. *Convictions from thence.*
Sect. XXVI. *Of the Quantity of Light.*
Sect. XXVII. *Convictions from thence.*
Sect. XXVIII. *The Uſefulneſs of the Divergency of Light.*
Sect. XXIX. *The Properties of the Divergency of Light.*
Sect. XXX. *Two great Uſes of the ſaid Divergency.*
Sect. XXXI. *Refractions, and their Uſes.*
Sect. XXXII. *The Cauſes of Refraction.*
Sect. XXXIII. *The Structure of the Eyes with reſpect to Light.*

Sect. XXXIV. *The Power of Bodies to reflect Light.*

Sect. XXXV. *The Air inviſible.*

Sect. XXXVI. *The Wonders of the Reflection of Light.*

Sect. XXXVII. *Experiments ſhewing that Light may become a Solid Body.*

Sect. XXXVIII. *Optical Experiments paſſed by.*

Sect. XXXIX. *A dark Chamber, and Convictions from thence.*

Sect. XL. *The Properties of the Rays of Light with reſpect to Colours.*

Sect. XLI. *The Diviſion of the Rays of Light in* Iſlandick *Chryſtal.*

Sect. XLII. *The Uſefulneſs of the Moon.*

Sect. XLIII. *Convictions from thence, and of the Eclipſes.*

Sect. XLIV. *The Advantages of Eclipſes.*

Sect. XLV. *The Light of the Moon is without Warmth.*

Sect. XLVI. *The Moon's Diſtance and Magnitude.*

Sect. XLVII. *Why the Light of the Moon gives no Heat.*

Sect. XLVIII. *The Cauſe of Ebbing and Flowing not inquired into.*

Sect. XLIX. *Two Syſtems of the World.*

Sect. L. *The immenſurable Magnitude of the fixed Stars.*

Sect. LI. *Of the Parallax of the fixed Stars.*

Sect. LII. *Whether the Starry Firmament be Solid or Fluid.*

Sect. LIII. *Probable Reaſons for its being Solid.*

Sect. LIV. *The amazing Greatneſs and Diſtance of the Stars.*

Sect. LV. *Convictions from the foregoing Obſervations.*

Sect. LVI, and LVII. *The Stars numberleſs, and Convictions from thence.*

Sect. LVIII. *Whether the Stars differ in Magnitude.*

Sect. LIX. *Variations in the fixed Stars, and Convictions from thence.*
Sect. LX. *Of the Planets.*
Sect. LXI. *The Magnitude of the Planets.*
Sect. LXII. *The Times of the Planets Revolutions and Diſtances from the Sun.*
Sect. LXIII. *The Velocity of* Venus *and* Jupiter.
Sect. LXIV. *The Calculation of the Revolutions of the aforeſaid Planets.*
Sect. LXV. *The Swiftneſs of one of* Jupiter's *Moons.*
Sect. LXVI. *The amazing Force that is requiſite to move* Jupiter.
Sect. LXVII. *Convictions from all the foregoing Obſervations.*
Sect. LXVIII. *The Evaſion of Atheiſts, and their Pretences.*
Sect. LXIX. *Thoſe Evaſions anſwered,* Firſt, *By the Orbs in which the Planets move.*
Sect. LXX. *The Properties thereof.*
Sect. LXXI. *The Atheiſts Evaſions anſwered,* Secondly, *By the Planets continual Approach to the Sun.*
Sect. LXXII. Thirdly, *By the Courſe of the Planets in an* Ellipſis.
Sect. LXXIII. Fourthly, *Becauſe their remoteſt Points extend to different Parts of the Heavens.*
Sect. LXXIV. *Convictions from the foregoing Obſervations.*
Sect. LXXV. *The Motion of the Planets about the Sun.*
Sect. LXXVI. *The Velocity of* Saturn, *and of his Ring.*

CONTEMPLATION XXV. *p.* 843.

Of the unſpeakable Number, and unconceivable Smallneſs of the Particles of which the Univerſe conſiſts.

Sect. I. *Tranſition to the Smallneſs of the Parts of which Bodies are compoſed.*
Sect. II. *All Bodies conſiſt of ſmall Parts.*
Sect. III. *Our Conceptions ſhould be rectified.*
Sect. IV. *A Cubical Inch contains a Million of viſible Particles.*
Sect. V. *A Cubical Inch of Water contains the like number of Parts.*
Sect. VI. *A Cubical Inch of Water rarified in an* Eolipile, *will yield above* 13300 *Millions of Parts.*
Sect. VII. *There may hang above* 13000 *Particles of Water to the ſharp Point of a Needle.*
Sect. VIII. *That a Drop of Water is diviſible into above* 26,000,000 *of Parts.*
Sect. IX. *Convictions from the foregoing Obſervations.*
Sect. X, XI, XII. *This Hypotheſis founded upon the Obſervations of Mr.* Lewenhoek, *namely, That a Drop of Water contains many more than a Million of Millions of Parts: The ſame applicable to all kind of Liquids.*
Sect. XIII, XIV, XV. *The Smallneſs of the Particles of Air, Fire, and Light.*
Sect. XVI. *How many Particles of Light fly out of a burning Candle in the Second of a Minute.*
Sect. XVII. *The Particles of Light compared with the Sand of the whole Earth.*
Sect. XVIII. *The Smallneſs of Parts in Solid Bodies, ſuch as Copper, Braſs,* &c.
Sect. XIX. *The Smallneſs of Parts in Solid and Fluid Bodies in General.*

Sect. XX. *Experiments ſhewing the determinate Properties of ſuch ſmall Parts.*
Sect. XXI. *Of the Smoak of* Benjoyn.
Sect. XXII, and XXIII. *Convictions from the Smallneſs of the Parts in general and in particular.*
Sect. XXIV, and XXV. *The Hand of God particularly manifeſted in the Uſe of theſe ſmall Parts.*
Sect. XXVI. *Convictions from the Smallneſs of the Particles of Air.*
Sect. XXVII. —*And from the Smallneſs of the Particles of Fire.*
Sect. XXVIII. *Convictions from all the foregoing Obſervations.*
Sect. XXIX. *Great Bodies are for the moſt part divided at firſt into ſmall Particles, before God is pleaſed to make uſe of them.*

CONTEMPLATION XXVI. *p.* 882.

Of certain Laws of Nature.

Sect. I. *What a Law of Nature is.*
Sect. II. *The Laws and Powers of Coheſion.*
Sect. III. *The Laws and Powers of Separation.*
Sect. IV. *The Unattrition of ſuch fine and tender Particles.*
Sect. V. *Two principal Laws of Nature, Percuſſion and Attraction,* &c.
Sect. VI and VII. *Gravity and its Effects.*
Sect. VIII. *Heavenly Bodies Gravitate towards each other.*
Sect. IX, and X. *A ſtrong Proof that Heavenly Bodies gravitate towards each other, and Convictions from thence.*
Sect. XI. *The Operations of Gravity in Bullets and Bombs.*
Sect. XII. *The Operations of Gravity in the* Catenaria, *or Chain-Curve.*

Sect. XIII. *There can be no ignorant neceſſary Firſt Cauſe deduced from a Series of ignorant Cauſes operating together.*

Sect. XIV. *The Firſt Motion proves a God, as does likewiſe the Continuation and Communication of Motion.*

Sect. XV. *The Reaſons produced by ſome for the Continuation of Motion ſeem too weak.*

Sect. XVI. *God acts reaſonably, incomprehenſibly, and according to his own good Pleaſure.*

Sect. XVII. *Other Reaſons againſt the Neceſſity of Natural Laws.*

Sect. XVIII. *The Proof of a God from the Motions of the Particles of Light.*

Sect. XIX. *The Exiſtence of a God proved likewiſe from the Laws of Mechaniſm in General.*

Sect. XX. *Tranſition to ſome Hydroſtatical Laws.*

Sect. XXI. *General Terms and Poſitions in Hydroſtatics.*

Sect. XXII. *The Order of the Experiments that are to be made for the Foundation of Hydroſtatical Laws.*

Sect. XXIII. *Of Fluids in Curve Tubes of equal Bigneſs.*

Sect. XXIV. *An Experiment to ſhew the Greatneſs of the Gravitating Power of Water.*

Sect. XXV. *Experiments proving that Fluids preſs upwards.*

Sect. XXVI. *An Experiment to ſhew the Greatneſs of this upward-preſſing Force.*

Sect. XXVII. *The Laws of Preſſure upwards and downwards.*

Sect. XXVIII. *An Experiment of the downward Preſſure of different Fluids upon each other.*

Sect. XXIX. *Oyl gravitates or preſſes upon Pickle in the ſame manner as Air upon Water.*

Sect. XXX. *The Greatneſs of the Preſſure upwards and downwards in ſeveral Fluids incumbent upon one another,*

Sect. XXXI. *Of the Preſſure upon equal Parts of higher or lower Horizontal Planes.*
Sect. XXXII. *Hydroſtatical Laws of ſeveral Fluids incumbent on one another.*
Sect. XXXIII. *The Preſſure upwards proceeds only from lateral Fluids.*
Sect. XXXIV. *Oblique Preſſures do alſo adapt themſelves to the Heighth of Fluids.*
Sect. XXXV. *The Hydroſtatical Laws of Oblique Preſſures.*
Sect. XXXVI. *Lateral Preſſures do likewiſe adapt themſelves to the Heighths or Depths of Fluids.*
Sect. XXXVII. *The Method of diſcovering the Greatneſs of the aforeſaid Preſſure.*
Sect. XXXVIII. *The Compariſon of the lateral and perpendicular Preſſure of the Air upon an equal part, ſhewn by an Experiment.*
Sect. XXXIX. *An Experimental Compariſon of the aforeſaid Preſſures in Water upon an equal Part.*
Sect. XL. *The Greatneſs of a Lateral Preſſure upon a Plane.*
Sect. XLI. *The Hydroſtatical Laws of Lateral Preſſures.*
Sect. XLII, *and* XLIII. *Two Experiments about Lateral Preſſures.*
Sect. XLIV. *The Lateral Preſſure adapts it ſelf to the Heighth, and not to the Breadth of Water.*
Sect. XLV. *The Lateral Preſſure of Water, with Air preſſing upon the ſame.*
Sect. XLVI. *The Augmentation and Diminution of the reſiſting Force, produces Motion and the Force thereof.*
Sect. XLVII. *Fluids are moved by, or rather after taking away a Reſiſtance ; and the Force thereof.*
Sect. XLVIII. *Tranſition to Hydraulicks, or ſome Hydroſtatical Examples.*
Sect. XLIX. *A Calculation of the Force of a Syphon.*

Sect. L. *Of a Fountain that ſpouts or ſprings higher than the Water that ſupplies it.*
Sect. LI. *Of a Fountain of* Hero, *the Stream whereof is longer than the Fountain is high.*
Sect. LII. *The Motion of Water in a Curve Tube.*
Sect. LIII, LIV, and LV. *A Hydroſtatical Paradox, ſhewn by two Experiments.*
Sect. LVI, and LVII. *Another Hydroſtatical Paradox confirmed likewiſe by an Experiment.*
Sect. LVIII. *Convictions from the ſurprizing Force of Water.*
Sect. LIX. *Convictions upon another Foundation.*
Sect. LX. *Without the Laws of Fluids, all Things would ſoon be in the utmoſt Confuſion.*
Sect. LXI. *Convictions from the ſame foregoing Obſervations.*
Sect. LXII. *Even Lead itſelf will float upon the Water, by the Preſſure thereof upward.*
Sect. LXIII. *Convictions from thence.*
Sect. LXIV. *Of Lateral Preſſure, and the Benefit thereof.*
Sect. LXV. *Convictions from the ſame.*

CONTEMPLATION XXVII. *p. 996.*

Of ſome Chymical Laws of Nature.

Sect. I. *Tranſition to other Laws.*
Sect. II. *Experiments ſhewing the Operation of Acids and Alcali's.*
Sect. III. *The aforeſaid Salts are changed and united by Efferveſcencies.*
Sect. IV. *Experiments ſhewing that Alcali's and Acids precipitate, or are ſeparated from each other.*
Sect. V. *Acid Salts diſperſed in many Bodies.*
Sect. VI. *Alcaline Salts likewiſe diſperſed in many Bodies.*

Sect. VII. *Convictions from thence.*
Sect. VIII. *The Preſervation of Things, proves a God.*
Sect. IX. *All Kinds of Philoſophy do, or muſt acknowledge Laws.*
Sect. X. *The Opinions of ſome Philoſophers about Fertility.*
Sect. XI. *The Air ſeems to abound with Salt-Petre: Seven Experiments ſhewing the Probability thereof.*
Sect. XII. *Salt-Petre ſeems to come out of the North: proved by three Experiments.*
Sect. XIII. *Salt-Petre becomes active by thoſe Particles in it that are the Sulphureous, ſhewn by Experiments.*
Sect. XIV. *Salt-Petre in Conjunction with the Rays of the Sun, does likewiſe render the Earth fruitful; ſhewn by an Experiment.*
Sect. XV. *Convictions from the foregoing Obſervations.*

CONTEMPLATION XXVIII. *p.* 1025.

Of the Poſſibility of the Reſurrection.

Sect. I. *The Objection of the* Sadducees, *anſwered by our Saviour,* Matth. xxij. *v.* 29.
Sect. II. *It is not a greater Miracle to Raiſe a Body, than to Create it.*
Sect. III. *Even the common Formation of Bodies, is leſs credible than the Reſurrection.*
Sect. IV. *The firſt Objection anſwered, namely, that we have no Parents in the Reſurrection.*
Sect. V. *The Second Objection, from the Smallneſs of the Parts after Corruption, anſwered.*
Sect. VI. *The Third Objection, from the Attrition of Particles, anſwer'd.*
Sect. VII. *The Fourth Objection, from the Union of thoſe Particles, with other Bodies, anſwered.* Sect.

Sect. VIII. *The Fifth Objection, That in the Particles of Bodies, we can't obſerve any ſuch Union, anſwered.*

Sect. IX. *The Sixth Objection, That theſe Particles are ſcattered too far from each other, anſwered.*

Sect. X. *The Seventh Objection, That the Particles of Matter would act with Choice or Knowledge, anſwer'd.*

Sect. XI. *The Eighth Objection, Concerning* Canibals, *or Man-eaters, anſwered.*

Sect. XII. *Conviction and Poſſibility of a Reſurrection.*

Sect. XIII. *Tranſition to another kind of a threefold Objection.*

Sect XIV. *Three Objections of the firſt Kind.*

Sect. XV. *Objections of the Second Kind.*

Sect. XVI. *Objections of the Third Sort from the Holy Scriptures.*

Sect. XVII. *Our Deſign here is not to deſcribe the Manner of the Reſurrection, which we muſt leave to God.*

Sect. XVIII. *A General Anſwer to all the Objections againſt a Reſurrection, taken out of Scripture.*

Sect. XIX. *A bare Hypotheſis is ſufficient to ſhew the Poſſibility of any Thing.*

Sect. XX. *There is a* Proper *or* Own, *and a* Viſible *Body.*

Sect. XXI. *This Diſtinction is acknowledged by all.*

Sect. XXII. *The* viſible *Body conſiſts of Fluid and of Solid Parts, and of Laws.*

Sect. XXIII. *The* own *Body conſiſts in a manner of no Fluid Parts, nor of Laws, but almoſt only of Solid Parts.*

Sect. XXIV. *The* own *Body conſiſts either of a* Stamen *or Principle unfolded only; or elſe of a* Stamen, *that grows and increaſes by the Addition of Foreign Particles.*

Sect. XXV. *How a Man may be ſaid to riſe again with his* own proper *Body, in the firſt Caſe.*

Sect. XXVI. *The* own *Body, tho' filled with other Matters, remains the* own proper *Body of the ſame Perſon.*
Sect. XXVII. *When any one dies, a great deal of that Matter which belonged to the* viſible *Body will be ſeparated therefrom.*
Sect. XXVIII. *The Three Objections of* Sect. XIV. *anſwer'd, in caſe the* own *Body conſiſts of a bare* Stamen.
Sect. XXIX. *The Objection in* Sect. XV. *anſwered, on the ſame Foundation.*
Sect. XXX. *The* viſible *Body of a Man may be very much emaciated, and yet remain his* viſible *and* own *Body.*
Sect. XXXI. *The* own *Body, tho' allowed to be a* Stamen *with an Accretion of Foreign Matter, conſiſts of nothing but Solid Particles, and chiefly of Bones.*
Sect. XXXII. *The Three Objections mentioned in* Sect. XIV. *ſolved, upon the Suppoſition that the* own *Body does conſiſt of a* Stamen *increaſed to a certain Bigneſs.*
Sect. XXXIII. *The Objections of* Sect. XV. *anſwer'd from the ſaid Principles.*
Sect. XXXIV. *Convictions from all the foregoing Obſervations.*

CONTEMPLATION XXIX. *p.* 1065.

Of Unknown Things.

Sect. I. *Tranſition to Unknown Things.*
Sect. II. *That there are many Things ſtill unknown.*
Sect. III. *Atheiſtical Objections anſwered.*
Sect. IV. *Unknown Things, tho' in themſelves not conceivable, do yet prove the Greatneſs of God.*

Sect.

Sect. V. *It is unknown, whether the Earth or the Sun moves.*

Sect. VI. *Such Ignorance proceeds,* Firſt, *From the Diſagreement of great Aſtronomers.*

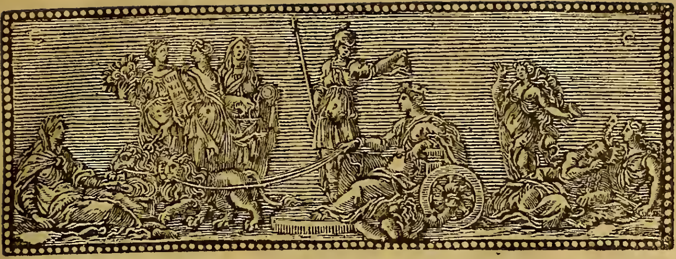
Sect. VII. Secondly, *Becauſe great Aſtronomers do themſelves own, that they are uncertain thereof.*

Sect. VIII. Thirdly, *Becauſe the Parallax from the Annual Motion is ſtill uncertain.*

Sect. IX. *Nothing can be inferred from the Expreſſions uſed by great Aſtronomers about the Earth's Motion.*

Sect. X. *The Simplicity of an Hypotheſis is not always an Argument of its Truth.*

Sect. XI. *A Concluſion from the whole, that neither the Sun's nor the Earth's Motion has ever been rightly proved.*



THE

Religious Philoſopher:

Or, the Right USE of the Contemplation of the Works of the CREATOR, *&c.*

Vol. III.

CONTEMPLATION XXIV.

Of the Viſible HEAVENS.

Sect. I. *Tranſition to the World in General, and to the Heavenly Bodies in Particular.*

TO aſcend now to that wonderful Structure of the glorious Heavens, and to ſhew from thence in a moſt convincing Manner, to all ſuch as ſtill doubt whether there be a Creator and Ruler of the Univerſe; there ſhould ſeem nothing more to be required, than to lift up our Eyes, and only to Contemplate the Firmament without Prejudice, and therein the incredible Greatneſs of that unmeaſurable Space, and of the Lights that are placed in it; and beſides, the wonderful Splendor of them all, the particular Influences which the Sun and Moon, among others, have upon our Globe, their unſpeakable ſwift Motions, hardly to be comprehended by human Imagination; and in the whole, the juſt and exact Obſervation of ſo many Laws and Ways to which ſuch a Number of Bodies have been ſubject for ſo many Ages, through ſuch vaſt and unknown Spaces, and with ſuch a terribly ſwift Motion as far exceeds that of a Cannon Bullet, and without being in the leaſtwiſe conſcious thereof themſelves: And this ought certainly to make an Atheiſt acknowledge, in caſe no Adorable and Powerful Direction had place in all theſe Matters, and theſe Bodies, with reſpect to their Magnitude and Velocity, were only moved by Chance, that they might likewiſe fall foul upon, or run againſt each other by the ſame Chance; and therefore that it would have been much better for him never to have been born, than to live in a continual Fear, that ſomething like this ſhould befal the Earth, which is his Dwelling-Place.

SECT. II. *Convictions from the Sight thereof.*

AND tho' one ſhould not carry one's Thoughts ſo far, let an Atheiſt ſuppoſe (to make uſe of the Emphatical Proof produced by *Cicero* in his Book of *The Nature of the Gods*) that from the Beginning of his Life he had been always ſhut up in the Cavern of a Mountain, in which he had ſeen no other Lights than little Lamps, nor no other Colours than thoſe of diſagreeable Rocks: Now if he had met with an Opportunity of ſpying through a Crack of this Mountain or otherwiſe up in the

Air, that Fire-Ball, ſo full of Luſtre and Beauty, the glorious Sun moving in the Heavens, and not only enlightening and warming this whole viſible Globe of the Earth, but likewiſe rendring it fruitful and capable of ſupporting both Men and Beaſts; and beſides all this, ſhould ſee the lovely Green of Trees and Fields, and the charming Colours of ſuch a Number of different Flowers; and could he help being exceedingly ſurpriſed and amazed, and forbear thinking how unconceivably Great and Glorious the CREATOR of all theſe Things muſt be?

SECT. III. *The Sun proved to be bigger than the Earth by the Eclipſes.*

NOW how ſtrong and irrefragable a Proof ſoever be drawn from the mere Contemplation of the Heavens, that it muſt have been a Great and Adorable CREATOR by whom theſe noble Bodies, and particularly the Sun, has been made, and by that Means ſo many Benefits and Advantages daily communicated to this our Globe; yet there is a great Error which has hinder'd almoſt all Men from judging of theſe Matters according to Truth: It is that Childiſh Prejudice which cauſes us to look upon the Sun to be a Body of the Dimenſions or Breadth of about a Foot, or a Foot and a half at moſt.

But thoſe who know by the Eclipſes of the Moon, that the Shadow A L Z (*Tab.* XX. *Fig.* 2.) which the Sun D G, by ſhining upon one Side of the Earth, caſts on the other Side, grows continually ſmaller from A Z to L, and runs out to a Pyramidal or Conical Figure A L Z, the Point or *Vertex* of which is at L; may, without knowing much of Opticks (whereby the ſame is proved) quickly infer, that the Sun D G is much greater

than

than the whole Globe of the Earth; for if the Sun were in its Diameter only *b b* equal to the Globe of the Earth A Z, it is plain that the Shadow, being then equal at A M N Z, would be every where, or at M N, as big as at A Z, and always remain ſo.

And in caſe the Sun's Diameter were *a a*, ſmaller than the Earth A Z, it is plain enough that the Shadow of the Earth would become continually larger towards P O, and farther.

So that Since it appears, by undeniable Obſervations in the Eclipſes of the Moon, that the Diameter of the Shadow at the Diſtance of the Moon, is not equal to that of the Earth, nor becomes bigger when farther from it, but that growing continually leſſer, it makes the Pyramid A L Z; it will entirely ſatisfy thoſe that underſtand this, that the Sun D G, is bigger than the Earth A Z.

The Knowledge of this may perhaps in ſome manner deliver People from the aforeſaid Childiſh Prejudice, and raiſing their Aſtoniſhment, at the Power of their Creator, make them conſider the Sun in its true Magnitude. But this will be done much more effectually when they know, that, according to undoubted Aſtronomical Obſervations, we may ſafely ſuppoſe the Sun to be above a *Hundred Thouſand Times* bigger than the Earth. I know very well that this will appear altogether incredible to thoſe that are unexperienced in Aſtronomy; 1*ſt*, Becauſe the Ancients have not allowed the Sun to be more than *166* Times bigger than the Earth, and ſome not ſo much. 2*dly*, Becauſe the Diſagreement among the Aſtronomers themſelves, concerning the Sun's Magnitude, is the Cauſe that their Concluſions have little or no Weight with Ignorant Perſons.

To remove this ſtumbling Block, we ſhall endeavour, as far as the Brevity of this Diſcourſe will permit, to ſhew the Certainty of what has been advanced, and tho' we can't eaſily know the exact Magnitude of the Sun, yet it will appear plain enough, that a Hundred Thouſand Globes of the Earth being put together will not be larger than the Body of the Sun. But they who know this by the Principles of Aſtronomy may paſs by the following Demonſtration, and proceed to *Sect.* IV.

SECT. IV. *The Magnitude of the SUN proved from* ASTRONOMY.

A Brief DEMONSTRATION of the Foundation of the Aſtronomical Concluſions about the MAGNITUDE *of the* SUN.

THAT the *Aſtronomers* in their Calculations of the Bigneſs of the Sun, do proceed upon the ſame Principles and Foundations, as the *Geometricians* in meaſuring the Heighth of a Tower, a Hill, or the like, is obvious to all that underſtand any thing of Mathematicks. For which cauſe we may be equally certain of the Concluſions of the former, as of the latter, provided that the *Aſtronomers* can make their Obſervations as juſtly and accurately as the *Geometricians.*

To prove this Aſſertion a little more clearly:

I. They take the Semi-Diameter of the Earth A B (*Tab.* XX. *Fig.* 1.) for an *Unit,* in order to determine the Sun's Magnitude B G, with reſpect to the ſame.

II. They

II. They obſerve, after different Manners, (which we ſhall not here deſcribe) the Angle A C B, which is made at the Center of the Sun C, and takes in the half Diameter of the Earth A B. This they call the Angle of the *Parallax*, becauſe, if we look along the Lines A C and B C, which make this Angle (and conſequently from the Superficies of the Earth A, and from its Center B) to the Center of the Sun C, the ſaid Center C, ſeems to cover the Point I to thoſe that look at it from A, and the Point F in the Heavens K L, to ſuch as look at the ſame from B. This *Difference* of *Sight* they call the *Parallax* ; and foraſmuch as the Angle A B C is thereby determin'd, they are us'd, for Brevity ſake, to call this Angle the Parallax : And when they have found this Angle A C B at any Heighth of the Sun above the Horizon, they compute how much it amounts to when the Center of the Sun C is in the Horizon A I ; and this they call the *Horizontal Parallax*.

III. This Angle was firſt obſerved from the Ancients down to *Tycho Brahé*, to be about ——— ——— ——— —	03 *Min.* 00 *Sec.*
But by *Longomontanus*, a Diſciple of *Tycho Brahé*, reduced to	02 *Min.* 40 *Sec.*
And Laſtly, By *Kepler* after various Obſervations farther reduced to——— ——— — —	01 *Min.* 00 *Sec.*

IV. Afterwards another Method of Obſervation being found out, which was not liable to ſo great Miſtakes as the former, to wit, by the Moon's Diſtance ; *Ricciolus* has found that the aforeſaid Angle does not exceed 30 *Sec.* or half a Minute.

And this is alſo counted a great Conceſſion, ſince, according to Mr. *Whiſton*, it does not exceed 25 *Seconds*, 10 *Thirds*. And *Wendelinus* brings it yet down to 15 *Seconds*.

V. There is another Method brought into Practice by Monſieur *Caſſini* and Monſieur *De la Hire* in *France*, by Mr. *Flamſtead* in *England*, and other great Men elſewhere; to wit, by Teleſcopes arm'd with *Micrometers*, whereby, without any Danger of falling into ſo many Miſtakes, the ſaid Angle A C B may be obſerv'd with the utmoſt Exactneſs, in caſe it can bear, by reaſon of its Smallneſs, any Determination by us that dwell upon the Earth.

From whence the ſaid Angle is computed by *Flamſtead* (vid. *Whiſton. Prælect. Phyſ. Mathem.* p. 276.) by *Caſſini*, (vid. *la Hire*'s *Tab. Aſtron.* p. 8.) by Sir *Iſaac Newton*, (vid. *Gregory Aſtron.* p. 336.) to amount to but 10 *Seconds*.

VI. From all which 'tis plain, that in Proportion as the Means have become more certain, and the Inſtruments of Meaſuring more exact, it has been obſerv'd, that the Angle A C B of the Parallax of the Sun has conſtantly grown leſs and leſs.

And therefore that theſe abovemention'd Differences that have occur'd among the Aſtronomers, have only proceeded from the Moderns uſing better Methods and more exact Inſtruments than the Antients; but they are by no means to be accounted Diſagreements, as ſome unskilful Perſons have called them, ſince the Antients have only ſhown thereby how far they had attain'd, and the Moderns, how much farther: And this is the more remarkable, becauſe the ſaid Differences have only been found between the Antients and the Moderns; but ſo far as they occur between Antients and Antients, and Moderns and Moderns that have made uſe of the ſame Methods and Inſtruments, they are hardly worth the naming.

VII. Now

VII. Now to proceed. Since Aſtronomers have found in the Triangle A B C the Side A B or the Semidiameter of the Earth, with the Angle of the Horizontal Parallax of the Sun A C B; and knowing that the Angle B A C is a right, when the Center of the Sun C is in the viſible Horizon A I, they have found in this Triangle, two Angles and one Side, wherefore by Trigonometry, they may find out the Line B C, or the Diſtance of the Sun from the Earth.

VIII. Now this Diſtance B C of the Sun from the Earth being known, which is likewiſe one Side of the Triangle B D C, they ſtill ſeek for for two Angles in the ſame, they being here neceſſary to compute the Semidiameter of the Sun D C.

IX. To find this, they obſerve with their Inſtruments (which, by the way, exceed very much in Exactneſs thoſe of the Antients) the Angle D B G containing the whole viſible Breadth of the Sun, and this they term the *Apparent Diameter* of the Sun.

The half whereof is the Angle D B C or the *Apparent Semidiameter* of the Sun, ſo called, becauſe it contains the half of its Diameter.

X. There has not occurr'd, in the Courſe of Ages, ſo great a Difference in this, as in that of the *Parallax*; and conſequently likewiſe according to theſe three times which we have remark'd among the Obſervers before about the Parallax, (when the Sun is in its middle Diſtance, that is, between the fartheſt from, and neareſt to the Earth) the apparent Diameter of the Sun, or the Angle D B G is computed by

Ptolomy, to be————	31 *Min.* 20 *Sec.*
Copernicus, at about———	32 *Min.* 45 *Sec.*
Tycho and *Longomontanus*——	31 *Min.* ——

Ricciolus	31 *Min.* 56 *Sec.*
Huygens	30 *Min.* 30 *Sec.*
Newton, who much approves the Obſervations of *Caſſini* and *Flamſtead*	32 *Min.* 15 *Sec.*
La Hire, about	32 *Min.* 11 *Sec.*

XI. So that the higheſt Computation of the apparent Diameter amounting to 32 *Min.* 45 *Sec.* and the loweſt being but 30 *Min.* and 30 *Sec.* the Difference is no more than 2 *Min.* 15 *Sec.* the half of which being taken for the Angle D B C, produces only a Difference of 1 $\frac{1}{8}$ *Min.* that is, about $\frac{1}{15}$ Part of the whole.

XII. Whereas the greateſt Parallax being of 3 *Min.* and the ſmalleſt but of 6 *Sec.* the former is above 30 Times bigger than the latter, as we have ſhewn above by *Numb.* III, IV, V.

XIII. And from hence it is manifeſt, that the Variety of the Obſervations, in the apparent Diameters, may produce ſome, tho' but a very ſmall Difference; but in the Angle of the Parallax, it will occaſion a very great one in the Magnitude of the Sun.

XIV. Finally, foraſmuch now that in the Triangle D B C, is found the before-given Side B C, or the Diſtance of the Earth, and the half apparent Diameter of the Sun, or the Angle D B C; and moreover, the Angle B D C being a Right Angle, becauſe the Line B D touches the Circle D O G at D; it follows, that in the ſaid Triangle D B C, there are found two Angles and one Side, whereby the third, D C, or the ſought-for Semidiameter of the Sun may be found.

XV. We might now, after this manner, from theſe and the preceding Conceſſions, compute, firſt the Diſtance of the Sun from the Earth B C, and afterwards the Bigneſs of its Diameter D C.

But ſince our View here is only to ſhew the Magnitude of the Sun, and the Difference thereupon between the Old and Modern Aſtronomers, but not ſo much to enter into any Diſcuſſion of the Diſtance thereof, we ſhall make uſe of a more conciſe Method, which is nevertheleſs attended with a Mathematical Certainty, and will be obvious to ſuch as are experienced in Geometry.

And this conſiſts in the following Proportion, or Rule of Three; in which we ſhall uſe the Angles A C B and D B C in the ſtead of their Sines, which indeed would be moſt agreeable to Geometrical Exactneſs; but becauſe there reſults no conſiderable Difference from it, and yet the Calculation is much more convenient, we ſhall uſe it as other Aſtronomers have done. And thus it proceeds:

> *As the Angle* A C B, or, *the Horizontal Parallax of the Sun*, is, to *The Angle* D B C, or *the apparent Semidiameter thereof*; ſo is *The Earth's Semidiameter* A B, to *The Sun's real Semidiameter* DC.

And this Rule does not only obtain with reſpect to the Sun, but likewiſe to all other Heavenly Bodies whatſoever.

XVI. So that according to *Tycho*, taking the Parallax 3 *Minutes*, and the half apparent Diameter $15\frac{1}{2}$ *Minutes*, the Semidiameter of the Sun is greater than that of the Earth A B,——	$5\frac{1}{6}$ *times.*
And theſe Numbers being cubed, (foraſmuch as Spherical Bodies are to each other as the Cubes of their Semidiameters) the Sun is bigger than the Earth——	138 *times.*

XVII. According to *Ricciolus* the Parallax 30 *Seconds*, is to the apparent Semidiameter 15 *Min.* 58 *Sec.* as 30 to 958 *Seconds*, or 1 to $31\frac{14}{15}$; and conſequently the Semidiameter of the Sun D C is greater than that of the Earth A B——————	$31\frac{14}{15}$ *times.*
This being multiply'd cubically, makes the Globe of the Sun bigger than that of the Earth above——	31000 *times.*
XVIII. According to Sir *Iſaac Newton*, the Parallax 10 *Sec.* is to the apparent Semidiameter $16\frac{1}{8}$ Min. as 10 Seconds to $967\frac{1}{2}$ Seconds; and conſequently the Sun's Semidiameter is bigger than the Earth's ———	$96\frac{3}{4}$ *times.*
And this being multiply'd cubically, the Body of the Sun exceeds that of the Earth about————	900,000 *tim.*
XIX. Finally *la Hire*'s Proportion requiring 6 *Seconds* Parallax, they are to 16 *Min.* $5\frac{1}{2}$ *Sec.* apparent Semidiameter, as 6 *Sec.* to $965\frac{1}{2}$ *Sec.* or 1 to $160\frac{11}{12}$; accordingly the Semidiameter of the Sun is greater than that of the Earth————	160 *times.*
And according to the Cubical Multiplication, the Sun exceeds the Earth's Magnitude, at leaſt——	4,000,000*tim*

XX. From all which compared with one another we may gather,

Firſt, That the Semidiameters of the Sun have increas'd from full Five, or hardly Six; firſt to full 31, afterwards to full *96*, and laſtly, to 1*6*0 Semidiameters of the Earth; which, to thoſe that are not much vers'd in theſe Matters, ſince the the Numbers are not great, may ſeem probable enough.

Secondly, But that the Globe of the Sun itſelf ſhould grow from hardly 140 Magnitudes of the Earth, firſt, to 31000, and afterwards on a ſudden to *9*00,000, and laſtly, to the Size of four Millions of Times greater than the Globe of the Earth, is ſuch a ſurprizing thing, that they who are not uſed to theſe kinds of Calculations, muſt needs judge it impoſſible, and think that altho' all that has been ſaid about the Semidiameters were true, yet this would appear a Miſtake in Aſtronomy: But every one that underſtands Geometry knows that one is as ſure as the other.

So that we now ſee finally, that this Increaſe and Difference of the Sun's Magnitude, manifeſting itſelf in the Sequel of Time, was principally and moſtly occaſion'd by the continual Diminution of the Angle of the Parallax, ſince the ſmall Diverſity in the apparent Semidiameters might indeed contribute ſomething, but yet very little thereto. But its amazing Magnitude is now particularly to be aſcribed to the Cubical Multiplication of the real Semidiameter thereof.

XXI. Since therefore all that has been advanced, carries along with it a Mathematical Certainty in the manner of computing, it remains only to be inquired, whether the lateſt Aſtronomers have likewiſe rightly obſerved that the Angle of the Parallax is ſo ſmall, which we ſhall leave to the Study of thoſe that think themſelves concern'd cern'd therein; foraſmuch as the comparing the three Ways that were in Uſe from the Times of the Ancients, to *Tycho Brahé*, and from him in the laſt Age by *Ricciolus*, *Wendelinus*, and others, and now by Meſſieurs *Caſſini*, *Flamſtead*, and *la Hire*, would prove too great a Digreſſion, and take up too much room here.

This is certainly true, and obvious to all that underſtand the Science of Aſtronomy, that the Antients, according to their own Confeſſion, could hardly be certain to a Minute in their Calculations of the Heavenly Bodies, even with their largeſt Inſtruments; and that the following Methods have had great advantages above the former, both in proceeding more certainly, and in coming much nearer; becauſe that the Angle, which was neceſſary to them for computing the Sun's Diſtance, was ſo much greater, compriſing the whole Space between the Moon and the Earth, which is about ſixty Times as large as the Semidiameter of the Earth, of which the Antients were obliged to make uſe, which renders the Miſtakes of the latter in their Obſervations ſo much ſmaller than thoſe of the former. But the Moderns, by the help of their Teleſcopes and Micrometers, ſeem to have brought this Science of Aſtronomy to as great a Perfection as it is poſſible for Men to do, making the Firmament itſelf ſerve them for a Quadrant by the means of the afore-mention'd Inſtruments and proper Pendulum-Clocks; and ſo, with no leſs Certainty than the former, they are able to make their Obſervations to a few Seconds.

SECT. V. *It may be ſhewn, with ſufficient Certainty, that the Sun is above* 100,000 *Times bigger than the Earth.*

BUT if the Parallax of the Sun does ſtill remain immenſurable to thoſe Obſervers that can meaſure every thing with ſo much Exactneſs, eſpecially if they endeavour to meaſure it about the neighbouring Planets, *Mars* and *Venus*, which (if their Diſtance alſo do not hinder) have Parallaxes much greater and more capable of Obſervation, and then make their Calculation of the Parallax from the Sun's and Planets Diſtances, (the Ratio whereof is better and ſufficiently known to them) it may be inferr'd, that it conſiſts in a very few Seconds or leſs, if they obſerve and diſcover it after this Manner. And therefore that we may conclude upon juſt and true Principles, that altho' theſe Magnitudes which the preſent Aſtronomers do aſcribe to the Sun, can't be ſo nicely determin'd, by reaſon of the Smallneſs of the Parallax (as all of 'em, even the chiefeſt, allow, and whereof I could produce many Proofs) nevertheleſs the ſame muſt be unconceiveably great. And in caſe we ſhould not admit of the 160 Semidiameters of *la Hire*, and conſequently of the Magnitude of the Sun above four Hundred Thouſand times bigger than the Earth, yet we can't think thoſe of Mr. *Huygens* ſo much to exceed the Truth, who makes the half Diameter of the Sun equal to 110 of thoſe of the Earth, and its Magnitude conſequently 133,100 more than that Earth; which as, it is eaſy to compute, does rerequire a Parallax of eight, or near nine Seconds.

Or we may come yet nearer, and take the Calculation which Sir *Iſaac Newton* makes uſe of in his *Theory of the Moon*, which ſuppoſes the Sun's Semidiameter to be $96\frac{3}{4}$, and its Magnitude to be 900,000 Globes of the Earth. Yea, if we take that of *Flamſtead* and *Horrox*, of about 12 Seconds (*vid. Newton Princ. Mathem.* p. 414.) which is twice as large as Mr. *La Hire*'s; we ſhall find yet more certainly, that no conſiderable Error is committed in aſcribing too great a Magnitude to the Sun, tho' that includes in its Semidiameter above 80, and in its Magnitude above 500,000 times that of the Earth.

Wherefore ſuppoſing (as we have done, *Sect.* III.) that the Sun is 100,000 as big as the Earth, we may be ſufficiently aſſured, that we rather make it too ſmall than too great; ſince the Parallax in this Caſe of about 21, is at leaſt bigger than 20 Seconds, and admitting with Sir *Iſaac Newton*, the apparent Semidiameter to be $16\frac{1}{8}$ Minutes, we find the Sun's real Semidiameter to be barely $46\frac{1}{2}$. And that no Error is committed here in allowing too much to the Sun, appears from hence, That the Obſervations (as Sir *Iſaac* himſelf owns in the Place above) of *Kepler*, *Ricciolus* and *Wendelinus* don't allow the Parallax to be much greater than 20 Seconds; tho' they have not us'd the accurate Method of *Caſſini* in their Obſervations, which renders this Parallax yet much ſmaller.

Again, becauſe (as appears by *Sect.* IV.) *Wendelinus* himſelf, after his Method, makes it 15 Seconds, which is ſo much leſs than 20.

Laſtly, The Teſtimony of the ſo often prais'd Sir *Iſaac Newton*, is of great Weight in this place, who making the Parallax to be 20 Seconds, ſays, That he chooſes rather upon that Occaſion to make it too big than too little; whereby he does not obſcurely inſinuate, that the ſame ought really to be taken ſomething ſmaller.

From whence then it follows, that the Diſagreement between the firſt and the laſt Aſtronomers does not prejudice the Truth of the Concluſions of the latter, about the determining the Sun's Magnitude; and that it is not too large a Conceſſion to allow it to be at leaſt 100,000 times as big as the Earth.

SECT. VI. *Convictions from the foregoing Obſervations.*

CAN it now be imagined, that ſuch a dreadful Globe of Fire, which is above 100,000 times bigger than our Earth (and one might more truly ſay above a Million of times, according to the aforeſaid Demonſtration) has been produced by mere Chance, and for ſo many Ages continued to diſcharge thoſe great Functions, of which all the Inhabitants of the Earth are daily ſenſible? And can any one perſwade himſelf that a Sea of Fire, of ſo aſtoniſhing an Extent, could have been contained within its Bounds, and in the Order and State we find it in, without the continual Direction of a great and wonderful Power and Wiſdom? Whereas there is no Matter known to Mankind, which with reſpect to us operates with more Fury, and, if it be in any Quantity, more ungovernably than Fire, of which there comes down to us daily (as the Burning-Glaſſes prove) ſo much from the Sun, either in, or with the Light thereof. And ought not the *Hypotheſis*, that Chance, (or ſomething elſe that is entirely ignorant of its own Actions, is the productive Cauſe of the Sun) make every one, even the boldeſt Atheiſt himſelf, live in a perpetual Fear; that by ſo continual a Motion and Raging of ſuch an un-

unconceivably great Quantity of Fire and inflamed Particles, or that ſometime or other, by the Deſcent of a much greater Quantity at once of this Matter from the Sun, along the ſame Way in which its Rays proceed at preſent, might ſet every thing on Fire upon the whole Globe; or that the Sun having conſumed the Food of that Fire, might change its Nature, and ceaſe to communicate its Warmth and Light to us; by which Means the whole Earth would be turned into the moſt diſmal Dungeon that any one can poſſibly conceive. How much more eaſie then and happy do thoſe Men live, who acknowledging the Maker thereof for an Almighty God, and their Gracious Benefactor, know that every thing, and that even this dreadful Globe itſelf, of Light and Fire, can only ſtir and move according to the Good Pleaſure of him that is the Lover of Mankind; and who, to deliver us from ſuch a well-grounded Apprehenſion, has declared expreſly in his holy Word, *Gen.* viii. 22. That *while the Earth remaineth, Seed-time and Harveſt, and Cold and Heat, and Summer and Winter, and Day and Night ſhall not ceaſe*; which Promiſe has been made good for ſo many thouſand Years.

SECT. VII. *The Sun's Diſtance from the Earth.*

Now if we paſs on from the Magnitude of the Sun (of which I hope thoſe that underſtand what has been already ſaid are fully convinced) to its Diſtance from the Earth, to the end that we may likewiſe therein rectify thoſe miſtaken Notions, which even from our Childiſh Years we have conceived about it, and which we can ſcarce fancy to be more than the Space of a Mile from us, an unlearned and unexperienced Perſon will not be leſs aſtoniſhed than he was before, when he hears us declaring, that we do not make too large an Allowance for the Sun's Diſtance, if we maintain for a certainty, that it amounts to above 1000 Semi Diameters, or Thickneſs of the Earth.

That the Sun is very far from this Globe may be proved by the Sun-Dials and otherwiſe, which we ſhall now paſs by, only ſhewing, as we have done before in *Sect.* IV. that the Diſagreement of Aſtronomy, with reſpect to the various Diſtances of the Sun, are only occaſioned from hence, that the Moderns are furniſhed with ſo much better Inſtruments or Methods for obſerving the Sun's *Parallax* than the Ancients; ſo that the ſmaller this continually appears to be, ſo much the greater is the Sun's Diſtance from the Earth.

To ſet this Matter in a clearer Light, for the Benefit of thoſe that are not skill'd in Aſtronomy.

Let the Semidiameter of the Earth, A B, *Tab.* XX. *Fig.* 3. (as in *Sect.* IV. *Numb.* VII.) be taken for an Unit, the Angle of the *Horizontal Parallax* of the Sun A C B in the Triangle A B C A, being likewiſe known by Obſervations: Then, ſince B A C is a Right Angle, the Diſtance of the Sun from the Earth, or from the Line B C, may be eaſily found by Right-lin'd Trigonometry: This Operation will be readily perform'd by ſuch as only underſtand that Way of Computing.

Suppoſing then A C B *to be the Angle of the Parallax*:

With *Tycho Brahé* of three Minutes, we find the Diſtance B C to conſiſt of Semidiameters of the Earth to the Number of — — — —	1150
With *Ricciolus* of 30 Seconds, barely —	7000

With

With *Newton*, *Caſſini*, *&c.* of 10 Seconds BC is full	20,000
With *Huggens* between 8 and 9 Seconds,	24,000
And with *La Hire* of but 6 Seconds, to full	34,000
And if (as has been done before) we ſuppoſe the Sun to be 100,000 times bigger than the Earth, the Parallax ACB will be about 20 Seconds (computing the apparent Semidiameter of the Sun to be 32¼ Minutes) and the Diſtance of the Sun from the Earth will amount to Semidiameters thereof,	10,000

Now ſince we can be aſſured from the ſo exact Obſervations of the greateſt Modern Aſtronomers, that the Parallax ACB is not more than of 20 Minutes, we cannot conclude with the ſame Confidence as a Geometrician can meaſure the Diſtance of any two Places on the Earth, how great the true Magnitude of the Sun, and how far its Diſtance is from us; but it may be concluded by a Geometrical Certainty, beyond all manner of doubting:

Firſt, That the Sun is *one hundred thouſand* times as big as the Earth.

And, *Secondly*, That its Diſtance from us is not leſs than *ten thouſand Semidiameters* of the Earth.

SECT. VIII. *Convictions from the foregoing Obſervations.*

NOW ſince it is indiſputably true, that if the Sun had been placed much nearer to the Earth than we find it, nothing leſs could have been expected than a Total Conflagration thereof; and in caſe it had been much more remote, the Earth would have refuſed to produce its Fruits for the Support of thoſe that dwell upon it. Can any one imagine again, that it is without Deſign, that this great and terrible Fire among ſo many numberleſs Places that it might have poſſeſſed in the great Space of the Univerſe, with reſpect to the Earth, ſhould be fixed juſt there only, where it can cauſe ſo much Good and ſo little Harm to this Globe? Now if ſo unhappy a Philoſopher (who maintains that the Sun has by meer Chance only acquired juſt that Place which is ſo uſeful and advantageous to the Earth, and all that is upon it) be a Mathematician, let him compute how many Places (in which the Sun might have been placed by the ſame Chance) are to be found in the vaſt Convex of the Starry Heavens, and how many thouſand to one it would have been, but that the Sun might have been fixed in one of 'em, where it would have been entirely uſeleſs to the Earth.

SECT. IX. *The Earth for Conveniency ſake ſuppoſed to ſtand ſtill.*

THIS ſeemed to be ſufficient to ſerve for a Conviction to ſuch as ſtill doubted of the Wiſdom of the Maker. But ſince Cuſtom, that ſeems to cloud our Reaſon with Stupidity and Inſenſibility, cauſes moſt Men to look upon this ſurprizing Wonder, like the Beaſts without Attention, we muſt adviſe all thoſe who ſtill find themſelves but little affected by the common Notices of what they ſee daily paſſes in the Sun, briefly to contemplate with us a few Particulars thereof, with reſpect to the Earth, in which (we here declare once for all, that) we deſign to uſe the ſame manner of Speaking and Figures that are agreeable with the Notions of *Tycho Brahé*, and are adapted to thoſe Globes, by which a quieſcent Earth and a Sun, moving about it are expreſſed. Thoſe that embrace the other Hypotheſis with *Copernicus*, namely, that the Earth moves about the Sun may keep the ſame Meaning, and adapt it to their own Opinions, as they muſt do in the moſt, if not in all the Works of the greateſt Aſtronomers; which, tho' they defend the Opinion of the Earth's Motion, yet in their Calculations concerning *Sphericks*, or the Circles and Angles which they make, do likewiſe make uſe of the ſame Figures and Expreſſions as are founded upon the Immobility of the Earth; as is well known to thoſe that have read their Books, and even the Writings of *Copernicus* himſelf.

SECT. X. *The Sun's Diurnal Motion.*

NOW if any Body were to have his Dwelling upon the Globe of the Earth *p e m f* *Tab.* XVI. *Fig.* 1. and would make himſelf and all other Men happy, would not his firſt Care be (in order to avoid living in perpetual Darkneſs) that the ſaid Globe ſhould be enlighten'd? Now this is performed by the Sun (for Inſtance) at E.

But when this is done, if the ſaid Sun E ſtood always immoveably over the Point *e*, it would be there always Day, and exceeding hot; but on the contrary it would produce a perpetual Night and continual Cold at *f*, both which would be very inconvenient; foraſmuch as in the laſt Caſe, tho' the Fertility of the Earth were not thereby diminiſhed, yet all Pleaſure; and in the firſt Caſe too, our moſt agreeable Reſt would be obſtructed.

To prevent all this therefore, it ſeemed again neceſſary, that this Sun ſhould move round the Earth in ſuch a Circle as E T F S E, in order to enlighten the ſame, and render it fruitful on all ſides, and not to ſtand always ſtill againſt one part of it; now this happens by the ſame Sun's moving round the Earth every twenty four Hours.

SECT. XI. *The Sun's Annual Motion, Declenſion, and the Seaſons of the Year.*

BUT now altho' the Sun ſhould daily enlighten and warm the Earth, yet if it were not to move in the aforeſaid Circle E T F S E, this ill Conſequence might again be expected from it, namely, that every thing upon the Earth, within the Segment of the Circle *e f*, would be ſcorched by its Heat; and other Parts of the Earth upon which the Rays of the Sun fell more obliquely, would be render'd barren by Cold. Wherefore, that the greateſt part of the Earth might not remain uſeleſs, 'twas requiſite again, that the Sun in its Circulation ſhould be ſerviceable to more parts of the Earth; and this again we ſee performed by the Sun, when it *recedes* or *declines* from the *Equator* E F on both ſides, to A Northward, and to C Southwardly, whilſt it always moves in the Circle A Y D, which the Aſtronomers call the *Ecliptic*, or *Sun's Way*. In this Circle it moves daily about one Degree, or the 360th part of a Circle from the *Weſt* to the *Eaſt*, whilſt in the ſame Space of Time it circulates from *Eaſt* to *Weſt* at an equal Diſtance from the *Equator* E F, of which circular Motions the two extream ones, A B and C D, are here deſcribed; the laſt of which it performs in one Day, and that in the *Ecliptic* A Y D, in 365 Days, or in a Year; and it is this Diurnal Motion that produces Day and Night, and the Annual, the four Seaſons of the Year: So that for Inſtance, 'tis Summer upon thoſe Parts of the Earth, *a* and *g*, when the Sun is at A in its Way A Y D; and Winter when the Sun is at D; and Autumn and Spring when it is upon either Side of the Globe, in the middle between A and D.

SECT. XII. *The great Uſe of the aboveſaid Motions.*

Now by theſe Motions, beſides the preventing thoſe great Inconveniencies, which would ſurely come to paſs, if one continual burning Seaſon, or an all-congealing Cold ſhould always prevail in the ſame Region of the World; we find that moſt of the inhabited Places of the Earth are enlightned and warmed, according to the Manner and Meaſure that is moſt agreeable to the Nature of the People and Fruits that belong to it: This Diverſity of Seaſons, and Diſtribution of Heat and Cold, being alſo the Cauſe that ſome Lands are diſpoſed and adapted to produce Spices, and ſome particular Kinds of Fruits, and other Countries others; whilſt in the mean time this general Benefit is enjoyed by all Mankind, tho' diſperſed over the whole Face of the Earth, by the Means of Trade and Shipping, by which every Nation may abound with thoſe Commodities that are not the natural Produce of its own Land.

SECT. XIII. *Convictions from the foregoing.*

BEFORE I proceed any further, let me aſk thoſe Philoſophers, who deny the Wiſdom and Goodneſs of the Supream Director of all things, Whether upon ſeeing any Royal or Princely Garden, they would ever pretend to ſay, that no Art nor Method had been uſed therein by the Gardener; tho' they ſhould obſerve, that in order to cauſe thoſe Plants to grow, which could not bear the Coldneſs of that Climate, Glaſs-Caſes, and Places with Stoves and other Conveniencies, had been prepared to make 'em enjoy as much Warmth as poſſible; whilſt on the other hand, Arbors and ſhady Places were provided for other Plants that could not bear much Heat? And whether they would not be convinced upon ſeeing the great Variety and ingenious Diſpoſition of the Plants, Flowers and Fruits in ſuch a Garden; that it was not Chance, nor an ignorant Cauſe, but the Skill of a judicious Director, which had exerted itſelf in all theſe things, and whoſe Deſign was to cauſe the Maſter of the Garden by ſuch a coſtly *Apparatus*, and by contriving ſo many different Degrees of Heat, to reap the Benefit of his Labours, and to enjoy the Refreſhment of thoſe Fruits which his own Climate and Air were not able to produce?

And can any one that is admitted to contemplate the Agreeableneſs of ſuch a Garden, tho' he ſhould not ſhare in the Fruits thereof, think himſelf obliged to thank the Owner for his Goodneſs, in ſhewing him the Secrets of his Art, and the wonderful Uſes of the Plants; and yet be no ways affected with the Goodneſs of the Great Creator of ſo glorious a Body as the Sun is; by the Warmth of which, the whole Earth is turned into a Pleaſure-Garden and a fine Park, as may appear in *Tab.* XVI. *Fig.* 1. where the Torrid Zone, *a*, *b*, *c*, *d*, repreſents the Orangery, or Place in which thoſe Fruits that require the greateſt Heats are produced; whilſt others, that require a more moderate or even a cold Air, do meet with the ſame in the two Temperate Zones, *a*, *g*, *h*, *b*, and *c*, *d*, *i*, *k*, or even farther towards the Poles in the Frigid Zones, *g*, *p*, *n*, and *i*, *m*, *k*, as far as the ſame remain fruitful. Thus we ſee, that there is not only a particular Climate appropriated to ſuch various Sorts of Plants and Trees, but that which renders the Obligation that all Men lie under to the adoreable Director of all theſe things ſtill greater, is, that his bountiful Mercy does not only diſplay therein a wonderful Wiſdom even to the cloying with Pleaſure thoſe that ſeek for the ſame; but likewiſe, that the Fruits produced thereby ſeem to be made for no other Purpoſe, beſides the Honour of the Creator, than for Medicines to Men in their Sickneſs, and for Food and Refreſhment to thoſe that are in Health; and in general, to render them happy in innumerable Inſtances, in which they are ſenſible of their Uſe and Convenience.

SECT. XIV. *and* XV. *The Morning and Evening Twilight.*

BESIDES what has been already ſhewn to be ſo wonderful in the Direction of the Sun in its daily and yearly Courſe, let an Atheiſt judge again, whether it is without a determinate End and Purpoſe, that the Rays thereof paſſing from a thinner into a thicker Medium, are refracted and turned away from their true Courſe, in order to produce the Twilights of Evening and Morning; whereas otherwiſe, upon the Setting of the Sun in all Places, a bright Day would be immediately changed into a Pitch-dark Night? And it may be eaſily perceived, that it is ſo ordered on purpoſe to be uſeful to Men, the Organs of whoſe Sight would be very much prejudiced, if the Tranſition from much Light to much Darkneſs were made all at once: But they that would be more fully informed in this Matter, need only look back to what we have ſaid in the 17th Contemtemplation about it.

That which may be farther obſerved here, is, with how much Reaſon God to convince *Job* of the Narrowneſs of his Underſtanding, has taken a Proof thereof from this Refraction of Light in the following Words; Chap. xxxviii. v. 12. *Haſt thou commanded the Morning ſince thy Days? And cauſed the Day Spring to know his Place?* Which laſt words are tranſlated by *Pool* and others. *Do you know perfectly the Place of the Twilight?*

To make this more intelligible to thoſe that are unexperienced in the Mathematicks, we have ſhewn above, in *Tab.* XIV. *Fig.* 3. that the Sun A being under the Horizon E Y, and caſting its Rays A H upon the Air at H, the ſaid Rays do not proceed directly, and in a ſtrait Line to D; but by being inflected, and making an Angle A H F, they are turned aſide to F, and refracted or broken at H, and thereby produce Day-break or Twilight to thoſe that live at F. Now it is known to every one by numberleſs Experiments, that according to the greater or leſſer Thickneſs of the Air, which varies in different Places, and in the ſame Place too, at different times, for many Reaſons, the Refraction does likewiſe differ: And therefore, that the Twilight, with reſpect to the extreameſt Parts where it is ſeen upon the Earth, or in the Air, cannot be determined by any Body; ſo that the ſaid Queſtion ſeems to carry this Meaning along with it. *Did you ever truly underſtand the different Thickneſs of the Air, both in your own and other Climates of the World, or the greater or leſſer Refraction proceeding from thence, and conſequently the Variations of the Morning and Evening Twilights, which are the Reſult thereof; or have you any Command or Direction over it?* To which Propoſition no Mortal will ever be able to return any other Anſwer, than that this has always been myſterious and impracticable to him; to convince holy *Job* whereof, was the Deſign of God.

Beſides what has been juſt now ſaid, there may be ſtill added theſe Reaſons, why 'tis impoſſible for Men to know exactly the Place of the Twilight: *Firſt*, Becauſe it ſeems neceſſary to be ſuppoſed, that the Sun is encompaſſed with a kind of an *Atmoſphere*, or Circle of Vapours (as the Earth is ſurrounded with Air) which upon the Account of the Sun's Nearneſs, does always ſhine, and is enlighten'd with the Fire thereof. *Secondly*, That the Sun ſhining upon the Parts or Vapours of the Air, the Rays are ſent back from ſome of 'em, as it were from a Looking-Glaſs by Reflexion, to the People who begin already to enter into Night; both which contribute very much to the Production of the Morning and Evening Twilight: See concerning this, *Gregory's Aſtronomy*, p. 127. where that great Mathematician (as if he intended to corroborate our Interpretation) uſes the following Expreſſion: *For theſe Reaſons the Bounds or Place of the Morning and Evening Twilights are not ſo certain:* Beſides which, he alledges ſeveral other Cauſes of this Uncertainty.

SECT. XVI. *The Weakneſs of our Conceptions.*

Now foraſmuch as all the great Services which the Sun renders to Men, Beaſts and Plants, are not to be number'd; foraſmuch as we ſee them daily renewed; foraſmuch as if we had been blind before, or remain'd always in Darkneſs, we ſhould be ſtruck with Wonder, and as it were tranſported at the Glory of the Sun's firſt Appearance. I have often ſtood amazed, how it was poſſible, that not only the Atheiſts (who act herein according to their Principles) but likewiſe others that acknowledge a God, and that pretend to worſhip him upon other Occaſions, are ſo little affected with all the Advantages that accrue to them from the Sun: For inſtance, how few are truly thankful for this great Benefit, that God cauſes the Sun to riſe in the Morning and enlighten the World, and to ſet in the Evening and produce the Night, by the Shadow of the Earth, in order to give Reſt to all Creatures that have been tired by the Labour of the Day; and ſo in other Matters.

But particularly even thoſe who are now entirely convinced of the Magnitude of the Sun, and its great Diſtance from the Earth, by the Mathematical Demonſtrations of the Aſtronomers, as well as by ſo many Places of the Holy Scriptures; ſuch as *Pſ.* lxxiv. *v. 16. Thou haſt prepared the Light and the Sun*; and *Pſ.* cxxxvi. *v. 7. To him that made great Lights*; and many others, have ſeen that the Spirit of God himſelf has appointed this great and glorious Body for a certain Proof of the Infinite Power of the Maker and Ruler thereof; and yet they hardly ſeem to have formed a right Notion of it. Beſides Cuſtom, the Weakneſs of our Imaginations ſeems to be the principal Cauſe thereof, which is unable, as well by reaſon of the Smallneſs of many Creatures that we are forced to view with Microſcopes, as becauſe of the Greatneſs of theſe heavenly Bodies, to repreſent them properly to us: And tho' no Body that underſtands Demonſtration can doubt thereof, yet every one will find how defective his Imagination is in forming juſt Ideas of their real Greatneſs or Smallneſs: Of this we have no occaſion to produce any Proofs; let every Man only examine himſelf, and ſee whether he does not diſcover within him, what many of the greateſt Mathematicians are obliged, with Shame, to confeſs, that they themſelves experience concerning this Matter: See what Mr. *Huygens* ſays about it in his *Coſmotheoros*, p. 124, and 125, who, to obviate this Weakneſs of the Humane Imagination, endeavours to make uſe of another Means, to impreſs more ſtrongly upon our Minds the Greatneſs of the Works of our adoreable Creator, and of the Diſtance of the Sun from the Earth; ſhewing, that if we ſuppoſe with him, that the ſaid Diſtance amounts to 12000 Diameters of the Earth (which yet is much leſs than what the Modern and moſt Accurate Aſtronomers do with good Reaſon maintain) that a Bullet ſhot out of a great Cannon, and moving in an equal Degree of Velocity, will be 25, or at leaſt 24 Years in paſſing from the Earth to the Sun.

SECT. XVII. *How much Time is required for a Cannon Bullet to paſs from the Earth to the Sun.*

NOW that what has been advanced by Mr. *Huygens* does not exceed the Truth, will appear:

I. Becauſe, according to the moſt exact Menſuration by the *French* Mathematicians, a Degree of a Great Circle upon the Globe of the

Earth amounts to 57060 *Toiſes* or Fathoms of ſix Foot; from whence it follows, that the Diameter thereof amounts to 6.538,594 of the like Fathoms, according to the ſaid Mr. *Huygens* and *Whiſton* in his *Prælect. Aſtron.* p. 13.

II. This being multiplied by 12000, the Diſtance of the Sun from the Earth, amounts to 78,463,128,000 of *French* Fathoms.

III. Now by the Experiments of *Merſennus*, a Cannon-Bullet advances in a Pulſe, or the Second of a Minute, about a hundred of the aforeſaid Fathoms, it therefore requires 784,631,280 Seconds to paſs with the like Swiftneſs from the Earth to the Sun.

IV. This Number is ſomewhat ſmaller than 788,940,000 which are the Sum of the Seconds of Twenty five Years, if one allows to each of 'em 365 Days and 6 Hours, as may appear by the Calculations of the ſaid Mr. *Huygens*.

SECT. XVIII. *How much Time is required for a Ship, or any Living Creature that can run Fifty Miles in a Day and a Night, to paſs from the Earth to the Sun, and Convictions from thence.*

NOW if the Swiftneſs of a Cannon-Bullet ſhould too much dazzle any ones Imagination; let him ſuppoſe a nimble Animal, ſuch as a Horſe, a Deer, a Bird, as alſo a Ship, either of which, if they can advance Fifty Miles every Twenty four Hours, will at leaſt require 1100 Years, either to run, fly, or ſail, ſuch a Space, as is between the Sun and the Earth, which may be eaſily computed, if one again ſuppoſes:

I. That the Sun is diſtant from the Earth 12000 Diameters thereof.

II. That a Degree, according to a Pilot's Calculation, being fifteen *Dutch* Leagues, the Circumference of the Earth will amount to 5400, and its Diameter to 1718 *Dutch* Leagues.

III. This being multiply'd with 12000, the Product of *Dutch* Leagues between the Sun and Earth, will be 21,616,000.

IV. This being divided by 50, or the Miles that a Ship will ſail in a Day, or a Horſe run, the Amount will be 412,320 Days, or about 1129 Years.

I thought I could not do amiſs in being ſomething the more large upon this Subject, and in ſhewing the Sun's Diſtance from the Earth after more than one manner; ſince Mankind are wont, upon this Occaſion, to repreſent to themſelves a Giant like a Dwarf; and the great Firmament, and thoſe glorious Bodies which it contains, and eſpecially the Sun, with reſpect to its Magnitude and Diſtance, incomparably ſmaller than they really are, and conſequently make the dreadful Power of the CREATOR, Contemptible inſtead of Wonderful and Infinite.

SECT. XIX. *The Swiftneſs of LIGHT.*

LET the Atheiſt now go on with us, and Contemplate that Wonder of all Wonders, that ſurprizing Creature the LIGHT, in its Properties only, ſo far as they are known to us, and in the firſt Place, its unconceivable, and (if it had not been proved experimentally, its altogether) incredible Velocity.

It may perhaps appear ſtrange to many, and even not to be admitted by moſt, if we ſhould affirm that Light requires ſome Time for the Parts of it to deſcend ſucceſſively from the Sun to us, and in that manner to be emitted from all Parts of that Glorious Body: Foraſmuch as the chief Philoſophers of the laſt Age, and many others of this, to whom the lateſt Obſervations of the Aſtronomers are not yet known, have thought, and with great Appearance of Truth too, that Light moved much after the ſame manner as a Stick lying between the Sun and us, whereof one End being protruded from the Sun, the other in an inſtant, and without any Space of Time, would be likewiſe moved; ſo that properly and according to this Hypotheſis, the Light does not come down to us from the Sun, but that which is near and about us is only put into a continual Motion by the Sun, or by the Power of its heavenly Matter. But they that are of this Opinion, will be yet much more ſhock'd, if we ſhould tell them, that this Light is not only derived to us continually from the Sun, and that it requires ſome Time to paſs to us, but even that it is protruded with ſo great a Swiftneſs, that it does not take up more than half a Quarter of an Hour, or about 7½ Minutes to paſs from the Sun to us, that is to ſay, to run ſo many Millions of Miles.

SECT. XX. *An Experiment to prove that Light really moves and comes from the Sun.*

AN actual Proof that Light moves, and that even when the Rays of it are collected in any Quantity, it will protrude Bodies it meets in its Courſe, and, as it were, blow them away, may be found in the Hiſtory of the *Royal Academy of Sciences*, 1708, p. 25. where Mr. *Homberg* relates, That a Light Matter, ſuch as the *Amianthus*, or Plume-Allum, being ſuddenly brought into the Focus of a Burning-Glaſs, upon a Wood-Coal, was driven off by the concurring Rays of Light; and that the Spring of a Watch, one End of which faſten'd in a Piece of Wood, being likewiſe placed in the Focus of a Glaſs of twelve or thirteen Inches, the Rays ſtruck againſt the looſe End of it, and cauſed it to move backwards and forwards juſt as if it had been thruſt with a Stick.

Now this does undeniably prove a great Swiftneſs of Light; yet this amazing Courſe of it, as it ſurpaſſes all Imagination, ſo with many would it exceed all Appearance of Truth, were it not that the ten Years Obſervations made by Mr. *Romer*, upon the Eclipſes of *Jupiter's Satellites*, had put this Matter ſo much out of Diſpute and Doubt, that the greateſt and moſt accurate Mathematicians have been forced to admit it upon the Strength of thoſe Experiments.

It ſhall ſuffice here, that we may not ſwell this Diſcourſe too much, to produce only the Teſtimony of Sir *Iſaac Newton*, tho' we could likewiſe add many others; theſe are the Words of that Gentleman in his *Princ. Philoſ.* p. 231. *Prop. 96. Lib.* 1. in the *Scholium*. *For that Light is puſhed on ſucceſſively, the Parts of it following each other, and that it paſſes from the Sun to the Earth in the Space of ten Minutes* (in the ſecond Edition he has alter'd it to *ſeven or eight Minutes*) *is now certain by the Appearances of* Jupiter's Satellites, *and confirmed by the Obſervations of ſeveral Aſtronomers.*

And when afterwards he publiſhed his Opticks, which are proved and illuſtrated by a Number of wonderful Experiments, we find him ſpeaking after this Manner, in the Eleventh Propoſition of the Second Book of the Third Part, p. 236. *The Light is tranſmitted in a certain Space of Time from the illuminating Body, and employs about ſeven or eight Minutes in its Courſe from the Sun to the Earth:* Whereupon he adds the Proof, the firſt Words of which are, *This was firſt obſerved by* Romer, *and afterwards by others, by Means of the Eclipſes of* Jupiter's

Satellites: In his ſecond Edition of his Opticks, he only allows *about ſeven Minutes* for this Paſſage of the Light.

They that deſire to ſee this more largely proved, may conſult Mr. *Huygens*, in his *Treatiſe of Light*; Mr. *Whiſton* in his *Prælect. Aſtronom.* and others. Beſides, that the Impoſſibility of the contrary Hypotheſis has been already ſhewn both by *Newton* and *Huygens*.

It is ſufficient for us, ſince we cannot here deſcribe the Particularities of Aſtronomy, to ſhew that this has been proved to be an unconteſtable and certain Argument, by the moſt accurate Inquirers into the Nature of Light, and that the boldeſt Atheiſts have no Reaſon to doubt thereof, unleſs they underſtand nothing of Mathematicks, or are ignorant of the lateſt Diſcoveries about the Properties of Light; or if they would be pleaſed to read the aforemention'd Aſtronomical Lectures of Mr. *Whiſton*, p. 229, and 230. where the *Recti-linear* Progreſſive Motions of the little Particles of the Light are largely handled and proved beyond all doubt; and where he ſhews, according to the niceſt Obſervations, that in half a quarter of an Hour's time, the Light paſſes through all that Space that is between the Sun and the Earth. And this being allowed, let them reflect with themſelves, whether it be credible, that it is by meer Chance, and without any Direction, that Bodies protruded with ſuch an amazing Swiftneſs, can always obey ſo many Laws without once varying in their unconceivable Progreſs, as it has been obſerved with reſpect to Light upon ſo many Occaſions; of which more hereafter.

SECT. XXI. *What would be the Conſequence, if the the Rays of Light ſhould become a Solid Body, and the Parts thereof adhere to each other.*

I SHALL here add, that I have been exceedingly affected with the Conſideration of the dreadful Velocity of Light, as often as I thought that if once ſo many Particles thereof ſhould adhere to each other, ſo as to compoſe a little Body, weighing no more than the tenth Part of a Grain, they would exert as great a Force by the Swiftneſs of their Motion in ſtriking upon any Body upon the Earth, as a Bullet of twelve Pound Weight ſhot out of a great Cannon.

Now that it is not impoſſible that Light ſhould become a ſolid Body, ſeems to be proved by that Matter which we at preſent call a *Phoſphorus*; which ſeems to conſiſt altogether, or for the moſt part, of a combined Fire or Light; foraſmuch as if we put the ſame into Oyl of Cloves, the Light thereof cleaves to the Oyl, and cauſes it to ſhine, as is known to the Chymiſts.

And now that no body may think ſuch a dreadful Force improbable, which we ſuppoſe to be in the deſcending Light, in the aforeſaid Circumſtances, let him ſuppoſe:

I. That Light paſſes in half a Quarter of an Hour, or 450 Seconds from the Sun to the Earth, which has been ſhewn above to amount to the Number of 78,463,128,000 *French* Fathoms.

II. It follows then, that this being divided by 450, the Light paſſes thro' 174,362,506 thereof in one Second or Pulſe. Let us ſuppoſe it, for, the ſake of a round Number, to be juſt 174,362,500.

III. Now a Twelve-pounder ſhot out of a Cannon is found to advance in the ſame time a hundred of theſe Fathoms.

IV. And it is manifeſt from the Laws of *Mechanicks* and the Doctrine of *Percuſſion*, that the Force of Projectiles, with reſpect to their Courſe and *Percuſſion*, are in the ſame Proportion to each other, as their Weights multiplied with the length of the Way which they make in the ſame Time.

Now for the ſake of thoſe that do not underſtand Mathematicks, we ſhall ſpeak a little more plain, and ſay; that a Bullet of ſix Pound, which in a certain Time runs the Diſtance of 200 Fathom, has twice as much Force, as a Bullet of twelve Pound, that runs but 50 Fathoms in the ſame Time; for 6 times 200 makes 1200, and 12 times 50 is but 600, or the half of 1200: After the ſame manner, a Bullet of 12 Pound running 100 Fathom, in a certain Time, has as much Force as a Bullet of 6 Pound that runs 200 Fathoms; of 3 Pounds and 400 Fathoms; of 2 Pounds and 600 Fathoms, in the ſame Time, &c. foraſmuch as the Weight of each of theſe Bullets being multiplied with the Way that they make in the ſame Space of Time, does always produce the like Number of 1200.

V. From whence we may infer, That in caſe an Aggregate of Light by its Velocity, does act with the ſame Force as a Bullet of 12 Pounds; then in order to find out the Weight of the Light neceſſary thereto, this Rule will have Place.

Wherefore, as the Length of the Way (or as 174,362,500 *French* Fathoms) which the Light goes in the Second of a Minute, is to the Length of the Way that ſuch a Bullet runs in the ſame time (or to 100 of ſuch Fathoms;) ſo is the 12 Pound-weight of the Bullet to the Pounds, or rather to the Weight of this Body of Light, that has the ſame Force.

VI. This Rule of Three being calculated, the Weight which the Light will have upon this Ocſion will be $\frac{12}{1743625}$ of a Pound.

And ſuppoſing a Pound, of 16 Ounces, to contain 7680 Grains, and thoſe Ounces to be *Troy-Weight*, the Weight of this Body of Light will be $\frac{92160}{1743625}$, or about $\frac{1}{18}$ of a Grain, as is ſaid before.

SECT. XXII. *Convictions from thence.*

NOW in order to be convinced not only of the Preſence, but likewiſe of the Neceſſity of a Divine Direction, ſince this dreadful Swiftneſs of Light is known, and ſince we find by Experience, in thouſands of Bodies, that Light will adhere to them, and become a ſolid Body, and they being kindled, it will appear again; let an unhappy Infidel once more ask himſelf, by what Law or Neceſſity of Nature it happens, that this Light never comes to be turned into a little ſolid Body, whilſt it is in the Sun, and ſo deſcend to us with its uſual Celerity; whereas Water is converted to Hail in the Air, and the Spots in the Sun ſeem to repreſent ſuch a Coheſion of Parts. Certainly if Chance only had place here, we cannot give the leaſt Reaſon why it ſhould not ſo happen, or why a dreadful Storm of theſe collected and compreſſed Particles of Light, ſhould not overſpread the whole Earth with utter Deſtruction in an Inſtant.

SECT. XXIII. *Light runs in ſtrait Lines.*

ONE of the Properties of Light is, its Motion in Right Lines, from whence, according to all Experiments, the Separation between Light and Darkneſs is juſtly deduced, and ſo likewiſe are the Shadows in *Perſpective*.

To give an Inſtance thereof: It is known that the Rays (*Tab.* XX. *Fig.* 3.) proceeding from the Points of the Sun, A and B, and thoſe that lie between, if they run directly forwards according to the Lines A P and B P; do form the Cone of Shadow or Pyramid, C D P; whereas on the contrary, if the Light did not move in ſtrait Lines, but in all kind of Curves, as Sounds are propagated, there would be no Darkneſs or Shadow where the Light could have no Acceſs, and conſequently no Separation between Light and Darkneſs.

SECT. XXIV. *Experiments to prove that Fire is produced by Light.*

ANOTHER Property of Light is, that it is either Fire it ſelf, or that it carries a great deal of Fire with it; and they that have a Mind to be ſurpriſed with the Powers and irreſiſtable Motions that do appear in this Fire, and by which it is diſpoſed (when united in any conſiderable Quantity) to conſume every thing in the moſt dreadful Manner; let them take an occaſion to view the Force of the new-invented Burning-Glaſſes of Meſſieurs *Hartſoeker* and *Tſchirnhaus*, or to read the Effects thereof. Lead and Pewter of a conſiderable Thickneſs are immediately melted by the ſaid Burning-Glaſſes; wet Wood will burn in an inſtant; Braſs and Copper, and even Iron Plates, will glow and melt preſently; and many People know how much Time is requiſite to cauſe hammer'd Iron to flow in the hotteſt melting Furnaces. Bricks, Pumice-ſtones, and Earthen Veſſels even full of Water will be diſſolved and vitrified, and the Water at the ſame time almoſt boyled. *Aſbeſtus*, Plume-allum, (which, according to the Teſtimony of *Kircher*, will even bear the Fire of the Glaſs-Blowers without any Alteration) as alſo Gold, upon which all the Powers of our common Fire have been in vain employed hitherto, (and of which mention is made above) are turned to Glaſs in the Focus thereof. They who deſire to ſee a more particular Account of theſe Matters, may conſult the *Act. Lipſ.* 1687. p. 52. 1688. p. 206. 1691. p. 518. and *the Hiſtory of the* French *Academy of Sciences.*

SECT. XXV. *Convictions from hence.*

NOW let an Atheiſt who knows from all this, that the Rays of the Sun do either conſiſt of ſo devouring a Fire, or do carry a great Quantity thereof along with them; or, if he has ever obſerved the terrible Force thereof in its Effects; I ſay, let ſuch a Man firſt repreſent to himſelf the almoſt incredible Velocity with which it comes down to us, and compare therewith the Force protruded by a little Flame of a Lamp, with which thoſe that blow Glaſs do make it glow and melt when they blow againſt it with any kind of Swiftneſs; and then let him tell us, whether he can think, without Uneaſineſs, that this great *Solar* Body tranſmits Fire to us with ſo terrible a Velocity, and that it is only owing to meer Chance that there does not come down a greater Quantity of this dreadful burning Matter, and overturn and deſtroy the whole Globe of the Earth with an unextinguiſhable Flame. And if he imagines, that this Earth is ſecured by fixed and neceſſary Laws of Nature from being conſumed with Fire, how can he prove that ſince one Day is fair, and there is ſcarce a Cloud to be ſeen in the Sky, but the next is continually rainy and ſtormy; may there not likewiſe ſuch an Alteration happen in the Sun to morrow, whereby every thing ſhall be burnt and conſumed. There is nothing more required to keep ſuch an Infidel in a continual Fear (if he be true to his own Principles) as the Conſideration of that Danger with which he is threaten'd every Moment, if the Light of the Sun were moved by meer Chance only, and without a Wiſe and Merciful Direction.

Sect. XXVI. *The Quantity of Light.*

Now let a Philſopher, who ſeeks for his unknown God in the true Diſpoſition and Structure of the Things of this viſible World, contemplate with us the amazing, and ſcarce conceivable *Quantity* of this *Light*, which is continually and inceſſantly tranſmitted from the Sun. We have ſaid ſomething upon this Subject before, when we treated of the Fire in the Air, and ſo far as it related to Light; but in order to be yet more fully convinced thereof, it is certain, by Experience, that this Light fills our whole Air, and all that Space that is between us and the Sun, at leaſt; that, excepting the Shadows, there is no Place, tho' never ſo ſmall, where it does not ſhew itſelf; [We expreſs our ſelves thus that, no Body may except againſt the Word *fill.*] We can perceive it in the two loweſt Planets *Mercury* and *Venus*; in the *Moon* which moves about the Earth; and even in the three uppermoſt Planets, *Mars*, *Jupiter*, and *Saturn*: From whence it is farther apparent, that this Light does ſufficiently fill all thoſe Places to which it extends itſelf, ſince wherever the Eye, or the Sun alſo, and thoſe other heavenly Bodies may be placed, either the Sun itſelf, or its Light, which falls firſt upon the Planets, and is from thence reflected to us, may be ſeen, unleſs ſome intervening dark Bodies prevent the ſame.

Now if any one would examine how great that almoſt inconceivable Space is, which is continually filled with the Light proceeding from the Sun, (to ſay nothing here of the fixed Stars) let 'em ſuppoſe with the modern Aſtronomers according to the Table by which Mr. *Huygens* made his *Automaton*, p. 447. that the Diſtance of the Earth from the Sun with reſpect to that of *Saturn* likewiſe from the Sun, is as 100 to 951; that is to ſay, *Saturn* is about 9½ times farther from the Sun than the Earth. Now 'tis plain enough, according to the modern Experiments, that the Diſtance between the Earth and the Sun amounts to about 12000 whole, or 24000 Semidiameters of the Earth, and therefore that the Diſtance of *Saturn* being 9½ times as great, it amounts to 228,000 Semidiameters of the Earth: For which Reaſon a Globe that would fill the Space between *Saturn* and the Sun, would contain 11,852,352,000,000,000 Globes of the Earth; theſe Globes being to one another as the Cubes of their Semidiameters: So that now every body that conſiders this almoſt inexpreſſible Number of Globes equal to that of the Earth, that are requiſite to compoſe one only equal to the Orb of *Saturn*, will eaſily agree, that the Space which is filled with the Light of the Sun, may be juſtly termed, in a manner, unconceivable.

But if we go farther, and in order to demonſtrate the Quantity of Light, conſider together with this Vaſtneſs of Space, the Swiftneſs of the Light, which, as we have ſhewn before, paſſes from the Sun to us in 7½ Minutes, or about the eighth Part of an Hour, it will appear thereby, that it paſſes from the Sun to *Saturn*, or to the utmoſt Part of the Orb (being deſcribed upon its Diſtance from the Sun as a Semidiameter) in 9½ times ſo many Minutes, that is to ſay, in 1$\frac{3}{16}$ Hour; at leaſt, if it be ſuppoſed that Light moves every where with the ſame degree of Velocity; for which reaſon this great Orb will be emptied again in leſs than five quarters of an Hour, if the Light paſſes thus ſwiftly on; and therefore there muſt proceed ſuch an unſpeakable quantity of Light from the Sun, as ſhall ſuffice in 24 Hours to fill ſo great an Orb about twenty times.

Sect. XXVII. *Convictions from thence.*

Now I leave it to an Atheiſt (who would not dare to maintain in the preſence of wiſe Men, that his Candle which ſerved to light his Chamber in the Evening, came there by chance) to judge himſelf, whether this glorious Sun, this wonderful Fountain, from whence for ſo many thouſands of Years there daily flows ſuch an unconceivable quantity of Light, can be believed by him to be produced without Wiſdom; and whether all the Benefits which it continually occaſions to thoſe that inhabit the Earth, cannot demonſtrate to him that a great Power (which ought juſtly to be dreaded by his Enemies) together with the Will as great to do Good to Mankind, had place in the Production of the Sun: And whether ſo prodigious a Body, with continual Streams of Light flowing from it, and which by its dreadful Velocity ſeems capable to hurry all things away with it, has been able to ſerve for warming and enlightning Mankind, and by fertilizing the Earth to preſerve them alive, without a wiſe Direction and Government, for ſo many Ages?

Let it not be objected here, that the Sun by conſtantly illuminating a Sphere as big as the Orb of *Saturn*, or bigger (ſince it is credible, that the Light of the Sun diffuſes itſelf beyond *Saturn*) and filling it ſo often with Light, and by having laſted as many Years as the World, may ſeem to have almoſt conſumed all its Light; and ſo if not quite waſted, yet muſt be greatly diminiſhed, ſince that is contrary to Experience: For in Anſwer thereto, beſides, that no Body can be perfectly aſſured, that Light does not circulate like the Blood in Animals, and after having performed its Courſe, comes back to the Sun again; which *Carteſius*, probably to avoid this Objection, ſeems to have thought: I ſay beſides this, the Particles of Light may alſo be conceived to be ſo very ſmall, that notwithſtanding they do ſo far fill this whole Orb, that the Interſtices or Spaces that are between, may remain entirely unobſerved by us; yet being taken all together, they may not perhaps amount to the quantity of one Grain of Sand; for which Reaſon there could be no Diminution perceived in the Body of the Sun in as many more Years or Ages.

Now as wonderful, and perhaps as incredible too as this may appear to many, it is nevertheleſs well known to the Mathematicians, that the great Space of which the Starry Heavens ſhou'd be ſuppoſed the upper Superficies, might be filled in ſuch manner with corporeal Particles, that no one Ray of Light, how fine and ſlender ſoever, if it had but a determinate Magnitude, could be able to paſs between the ſame, and conſequently the ſaid great Space would be abſolutely opaque. All which corporeal Particles, if they were joyned together, would nevertheleſs not only not make the quantity of one little Grain of Sand, but even not of the ſmalleſt Part thereof, provided its Magnitude were likewiſe determinate. See Dr. *Keil's Introduction*, p. 54, & 55.

SECT. XXVIII. *The Uſefulneſs of the Divergency of Light.*

BUT if an Atheiſt ſhould conſider this continual and ſwift Stream (as it really is) proceeding from the Sun, not only as it brings Light always with it, but likewiſe an actual Fire; he muſt be forced to confeſs, according to the Experiments of the Burning-Glaſſes, that if this Light and Fire ſhould deſcend to us in ſuch a cloſe and compreſſed Body as we find it is when the Rays of it are collected in the *Focus* of the ſaid Glaſſes, the whole Globe of the Earth with every thing belonging to it, would ſoon be reduced to a more dreadful Glowing than Metals put into Fuſion in a Furnace. Now it is ſure enough, that this fiery Light is more hot and deſtructive near the Sun, than in the aforeſaid *Focus*; ſo that in order to convert the Earth into a glowing Ocean, of which one can hardly think without trembling; nothing more is required, than that the Light ſhould come down quite to us with its Rays, as compact and cloſely united to each other, as it really is near the Sun.

This being laid down, let him ſeriouſly weigh with himſelf, whether he can think it to come to paſs without Wiſdom and Direction, that there is ſuch a Motion communicated to the Rays of Light, and ſuch a Law preſcribed to them, which they have ſtrictly obeyed hitherto for ſo many Ages, without once receding from 'em, tho' they themſelves are entirely ignorant thereof, and whereby the Earth, and even the Univerſe itſelf have ſtill been preſerved from this all-conſuming Fire. The Laws we mentioned to which Light is ſubject, are, that as ſoon as it comes from the Sun, the Rays of it are ſcatter'd and divided from each other, and continually more and more ſo, the farther they proceed in Right Lines. This the Learned expreſs by the term of the *Divergency* of the Rays.

Of this we have ſpoken before, when we treated of the buſineſs of Viſion, or Sight, and of Fire; and to avoid Repetitions, we ſhould have paſſed it by here, were it not that from this Divergency or Separation of the Rays of Light, there ſeem'd to reſult a Proof, which is alone ſufficient to cauſe an Infidel to ſee with indiſputable Clearneſs, that there is a God that governs this now ſo beneficial and uſeful, but otherwiſe ſo terrible, Subſtance of Light and Fire, and thereby preſerves from unavoidable Deſtruction, every thing that has Life and Being upon the Earth.

SECT. XXIX. *The Properties of the Divergency of Light.*

WE ſhall only add the following, to what has been ſaid before upon the ſame Subject, to the end that thoſe who are not verſed in Opticks and other parts of Mathematicks relating to Light, may have plainer Notions thereof: Let it be then ſuppoſed (*Tab.* XXI. *Fig.* 2.) that S is a Point in the Sun, from whence the Rays S *a* A, S *c* E, S *c* C, S *d* D, S *b* B, *&c.* in their Progreſs from S to A, C, D, E, continually diverge or recede as they move from each other: Now there need not be much pains taken to ſhew, that the ſame Rays which at the diſtance S B, fall upon the Plane Circle A E C D, when they are nearer to the Sun; and for Inſtance, when they have proceeded no farther from it than to S *b*, are all within the Circumference of a ſmaller Circle *a e c d*; and conſequently, that the Fire of which theſe Rays conſiſt, or at leaſt which accompanies them, is ſo much thicker, or preſſed together in the little Circle *a e c d*, than in the great one A E C D, as this laſt is bigger than the former; or to ſpeak in the Language of the Mathematicians, the Heat which the little Circle *a e c d* undergoes, is ſo much greater than that which the bigger Circle A E C D feels from the ſame Rays, as the Square of the Diſtance of the great Circle, or of S B or S A, *&c.* is greater than the Square of the Diſtance of the little Circle, or of S *b* or S *a*: That is to ſay, when S B is twice as great as S *b*, the Heat at *a e c d* is twice two times, or four times greater than at A E C D; and ſo S B being 100, and S *b* 5, their Squares are 100 times 100, and five times 5, or 10,000 and 25; and conſequently the Heat at *a e c d*: Is to the Heat at A E C D: As 10,000: To 25, or as 400 to 1, which is likewiſe confirmed by Experience.

From whence it is then manifeſt, that if one knows how much one Place is nearer to the Sun than another, one may likewiſe according to this Rule, make an exact Calculation how much more Heat is produced by the Rays of the Sun at one Place than at another upon occaſion of their Diſtance; and generally that 'tis true, that by how much the nearer any thing is to the Sun, ſo much the greater Heat it muſt undergo from the united and compacted Rays thereof; as alſo the farther it is from the Sun, the leſs will it feel of its Heat.

Now as this is known to be true by all Mathematicians, let an unhappy Atheiſt conſider in his Retirement, whether he thinks it can be by Chance, that a glowing Sea of Fire above 100,000 times bigger than the whole Globe of the Earth, is about the Sun at S, the burning Rays whereof S B, S A, S E, S C, S D, *&c.* come down with ſo unſpeakable a Swiftneſs inceſſantly, (and therefore in ſuch a Number as is hardly to be conceived) upon the Earth at A D C E; and yet that this terrible Fire does not immediately, and in the moſt diſmal manner conſume every thing upon it.

'Tis true indeed, that the Diſtance S B, which is between the Earth B and the Sun S, being of the Length of 12,000 Diameters of the Earth, may contribute ſomething thereto; but yet this beautiful Globe is by no means preſerved from the aforeſaid terrible Deſtruction by this only. To underſtand which, let it be ſuppoſed, that there comes down from the Point of the Sun S upon the Earth, the Rays S *a*, S *e*, S *b*, S *c*, S *d*, *&c.* without *Diverging*, or in parallel Lines, and cloſely joyned together; or (to render the Notion thereof yet clearer) that the ſaid Rays being near the Sun at the Point B, are diverged and ſeparated from each other as they go, but proceeding farther loſe their Divergency; and deſcending down by their Paralleliſm or Equidiſtance form the circular Column *a c m k*, it is plain, that all of 'em will fall upon the Circle *k m*, and there produce a Heat, which is ſo much greater than that which would be perceived in the great Circle A E C D from the ſame diverging Rays, as this laſt Circle is bigger than the little one *k m*. This appears from the Burning-Glaſſes, the Force of which does only conſiſt herein, that the Rays are collected into a ſmaller Compaſs; ſo that they give a clear proof of this Truth, that the Rays of the Sun being collected into a narrower Compaſs, even at ſo great a Diſtance from the Sun itſelf as is the Earth, are yet capable of producing a terrible Heat. From whence then it does follow certainly enough, that it is not ſo much the Diſtance of the Sun, but the Divergency or Scattering of its Rays more and more, which chiefly diminiſh the force of Burning; and that the ſaid Diſtance or Remoteneſs does hardly contribute more towards preſerving the Earth from an entire Conflagration, than by the diſſipating and ſeparating the Rays more and more from each other, in proportion to the Length which they run.

SECT. XXX. *Two great Uſes of the ſaid Divergency.*

FROM this Divergency of the Rays of Light from all Points whatſoever (which muſt be conſidered as a Wonder by all Men) we may deduce theſe two Advantages, which the adorable Creator beſtows upon us, and which we have before already hinted:

Firſt, That the Earth is thereby ſecured from being conſumed by the Sun.

Secondly, That by ſuch Divergency all Bodies are enlighten'd on all Sides by the Rays that are ſcatter'd upon 'em, and thereby render'd viſible to every one. Thus we find in *Vol.* I. *Tab.* X. *Fig.* 1. that the Rays of Light K P falling from the Candle K upon a Point P (for Inſtance upon the Point of a Needle) ſeparate themſelves from one another there, as well as at the Candle itſelf, and ſo render the ſaid Point viſible in every Part.

SECT. XXXI. *Refractions and their Uſes.*

BUT foraſmuch as (*Tab.* X. *Fig.* 3.) theſe Rays from A, diverging and filling the Space A S T, the ſame would alſo happen from all the other Points N, L, M, B, *&c.* of the Object A B, and therefore the ſame Rays diverging, for inſtance, from B and A, will be entirely mingled with each other at S O T, and ſo repreſent to the Eye at S T a confuſed Light of all the ſurrounding Objects, but no diſtinct View of any one; there ſeemed therefore ſomething to be ſtill deficient to render the Light compleatly uſeful to us; and that beſides the rectilinear and divergent Motions of Light, there was yet another Law requiſite, by which all the Rays proceeding from A or B might be again inflected towards each other, and gather'd together in ſo many particular Points *a* and *b*, which has been already proved to be the ſole Cauſe of diſtinct Viſion.

Beſides this, to the end that the Light may be as uſeful to us as poſſible, ſince the Sun when it Sets would turn the perfect Day in a very ſmall ſpace of Time into thick Darkneſs, and when it Riſes, would change a Night as dark as Pitch in a few Minutes into a bright Day; by which means our Eyes paſſing ſo ſuddenly from one Extream to the other, might be much prejudiced and weaken'd, as Experience often ſhews; there ſeemed to be a Means neceſſary to cauſe the Brightneſs of the ſtrong Light of the Sun to advance and recede gradually; and this is brought about by the Morning and Evening Twilights.

Now I wou'd ask an Atheiſt, who pretends not yet to be able to diſcover the wiſe Purpoſes of him that has preſcribed ſuch Laws to the *Light*, and which it ſtrictly obeys, Whether he could have found out a better way to avoid the abovemention'd Inconveniences, than by enduring *Light* with the Properties of Refraction, whereby, as we have already ſhewn, the two aforeſaid Difficulties may be obviated? And ſince they are actually prevented by this Method; what Reaſon has ſo unhappy a Philoſopher to deny the Wiſdom of the Creator and Ruler of ſo glorious a Body?

SECT. XXXII. *The Reaſon of the Angles.*

NOW to ſhew that theſe Refractions of the Rays of Light can't be aſcribed to mere Chance, let, (*Tab.* XXI. *Fig.* 3.) a Ray S O proceed from the Sun S to the Superficies of the Water F G; and ſuppoſe from the Center O a Circle F B G P deſcribed as large as you will, it is experimentally true, that the Ray B O does not proceed ſtrait forwards to R, but at O makes the Angle B O P, for which Reaſon the ſame Ray being thereby refracted proceeds from O to P, according to P O, which is termed the refracted Ray.

After the ſame manner the Ray *b* O, does not proceed ſtrait forwards to *r*, but breaks at O *p*: Now whether theſe refracted Rays O P and *p* O do likewiſe run in ſtrait Lines, or elſe as often as they meet with freſh Reſiſtance or Reverberations are again inflected, we don't here diſpute.

Now I leave any one, that is reaſonable, to judge whether he imagines it poſſible to happen without any Direction, that all the Rays O S, O *s*, and all others that with different Obliquity fall upon the Water F G, as here at O, with ſo dreadful a Velocity, with which they are protruded; and that being entirely ignorant of all things elſe as well as of themſelves, they can obſerve ſuch a Law without once departing from it, that their broken Rays, O P, O *p*, do exactly ever take the ſame Way; that (ſuppoſing the Lines A B, D P, *a b*, *d p* to be all at Right Angles to *a d*, which is likewiſe at right Angles with Reſpect to F G) the ſaid A B and P D, as alſo *a b* and *p d*, will always have the ſame Ratio to each other; ſo that to ſpeak more plainly, as A B is two or three times as long as P D, in all the other Incident

Rays, as here at *b o*, *a b* will be twice or thrice as long as *p d*; nor will there be, in ſo many Millions of Rays that fall in ſuch various Obliquities upon F G, and penetrate into the Water, one ſingle Ray to be found, notwithſtanding their ſurprizing Swiftneſs, that don't perfectly follow this Rule, at leaſt if all the Rays are of the ſame Kind.

SECT. XXXIII. *The Structure of the Eyes with reſpect to Light.*

AND as when we treated of the Eye, we mention'd the Properties of Light as an uncontеſtable Proof of the Wiſdom of the Creator; ſo whilſt we are here ſpeaking of Light, we ſhall briefly apply the Structure of the Eye, ſo far as it relates to Light, to the ſame Purpoſe; and the moſt obdurate Atheiſt, unleſs he abſolutely refuſes to liſten to any convincing Proofs, is intreated by us, that he would again attend to what we have ſaid in the Contemplation about *Viſion.*

SECT. XXXIV. *The Power of Bodies to reflect Light.*

BUT now tho' Light ſhould fall upon the Eye, and tho' the Eye were furniſhed with all the aforeſaid Qualities for receiving the ſame; yet that whole Diſpoſition, and all thoſe Properties would be in vain, and the noble Globe of the Earth would be of no more Advantage to the Inhabitants than it is to any Body now who is ſtark blind; unleſs beſides all this, the Bodies upon which Light falls had the Faculty of cauſing the ſame to rebound back from them, and to *reflect* the Rays thereof to all Places round about 'em.

Now ſince this Property occurs in almoſt all viſible Objects, will an Atheiſt ſay, that this was likewiſe by Chance, nor that the great End thereof was, to render Bodies viſible?

And if it ſhould appear to him too abſurd to aſcribe all this to meer Chance only, let him then tell us, what Neceſſity there is in the Combination of Cauſes, why almoſt all Bodies do enjoy this reflecting Power, with reſpect to Light; whereas there are many which in relation to others that ſtrike upon or againſt 'em, do not exert ſuch a Power, nor drive them back again with any Repercuſſion. Thus we ſee, for inſtance, That every thing which falls with any Degree of Swiftneſs upon ſoft Clay, remains ſticking in it, and is not reflected; and yet the contrary happens when thoſe exceeding ſwift Particles of Light fall upon the ſame; for how ſmall ſoever they be, they rebound from it, and thereby render the Clay viſible. We might relate many more Wonders concerning this Matter, which we ſhall paſs by here, having occaſion to ſay ſomething of them hereafter.

SECT. XXXV. *The AIR Inviſible.*

MOREOVER, ſince this Property of Reflecting Light, is in a manner common to all Bodies, excepting perhaps ſuch as are black (which by many is ſuppoſed to be occaſion'd hereby, namely that Bodies ſo tinged do not reflect any of the Rays of Light that fall upon them, for which Reaſon they have no other Idea of this Colour but as of meer Darkneſs) Now muſt we not herein again confeſs a wiſe Diſpoſition of the Great and Gracious Creator, who, notwithſtanding that he has made Water and many other fluid Matters viſible, yet ſeems to have excluded the Air only, for the moſt part, from that Faculty, notwithſtanding that that alſo in itſelf is viſible like other Bodies, and ſeems to be very well adapted thereto by its Elaſtical and other Properties, as appears when we compreſs a great Quantity of Air in the Pump, and then ſuddenly let it out again by the Cock? Now let an Atheiſt ask himſelf, whether this can appear to him to be ſo order'd without any Deſign or Purpoſe? And ſince the Air itſelf being thus viſible, and ſo far capable of ſtopping the Courſe of Light, would cauſe us to live as it were in a continual Fog, and hinder us from ſeeing conveniently moſt of the Objects about us, whether he does not obſerve, that this ſame adorable Wiſdom does here interpoſe after a wonderful Manner for the Benefit of Mankind?

SECT. XXXVI. *The Wonders of Reflection.*

AND to the end that many miſerable Philoſophers, who think they underſtand ſo well the Laws of Reflections and Refractions, ſhould not imagine that there are not more Wonders concealed in the ſame, and that their Underſtanding does perfectly extend itſelf thereto, let them give a ſatisfactory Reaſon of the Appearances mention'd by that accurate Philoſopher Sir *Iſaac Newton*, in his *Opticks*, p. 238, and 346, *laſt Edition*; and tell us what is the Cauſe that the Light paſſing from a Glaſs, and falling with a certain Obliquity upon a Place from which the Air has been exhauſted, does not proceed on, but returns back again to the Glaſs; and that when the Rays fall from the Glaſs upon the Air with an Oblique Angle of more than 40 or 41 Degrees, the ſame are likewiſe entirely reflected; whereas if they fall with a leſſer Obliquity, moſt of 'em will paſs thro' the

Air, ſo that the Light which paſſing thro' the Air upon the Glaſs, can make itſelf a way thro' the ſame, and yet the Light that paſſes from the Glaſs to the Air in the ſame Obliquity ſeems unable to make itſelf a Paſſage in a ſo much thinner Matter, whereby to purſue its Courſe.

They that have a mind to ſee many wonderful Circumſtances beſides theſe, may conſult the above-mention'd Places, and from the Experiments there related, may with Certainty enough infer, that we do not rightly underſtand the Nature of Light, with reſpect to its Reflections, whilſt we only conſider it as a Globe or Ball rebounding from any hard Matter.

At leaſt it is evident hereby, that there are Laws in Nature to which the Light is ſubjected, of which perhaps none of the Naturaliſts, if they had not thus found them true by Experience, would ever have thought.

SECT. XXXVII. *Experiments ſhewing that Light may become a Solid Body.*

I MIGHT have here forborn to have enquired into certain Queſtions propoſed by Sir *Iſaac Newton*, in his *Opticks*, p. 349. *Quæſt.* XXX. where that Gentleman ſeems to incline to the Opinion, that Light, beſides its being the moſt active Matter in Nature, may likewiſe become the Subſtance of palpable Things, and be converted into a ſolid Body; but ſince Mr. *Homberg* has put this Affair out of doubt by ſeveral Experiments recited in the Memoirs of the *Royal* French *Academy*, 1705. p. 122, *&c.* it ſeems not improper to ſhew here likewiſe this Uſe of Light. And, *Firſt*, That Light penetrates almoſt all Bodies, even thoſe that appear obſcure to the Eye, and paſſes thro' the ſame, as is ſufficiently known to ſuch as make uſe of good Microſcopes, ſince almoſt every Object that has been viewed therewith, provided they are but thin enough, do in ſome manner become tranſparent.

The ſaid Sir *Iſaac Newton* tells us in his *Opticks*, p. 223. That he has obſerved the ſame in a dark Chamber, when any Matter reduced to a proper Thinneſs, was placed before the Hole through which the Light would otherwiſe have paſſed; and he only excepts white metalick Bodies, which ſeem to reflect all the Light falling on them.

Secondly, If we ſuppoſe Flame to conſiſt for the moſt part of Light, we ſee that it turns to a ſolid Body in the burning of Chalk, and eſpecially in the making of *Minium* or Red-Lead from Lead-Aſhes, which after having burnt and glow'd a great while, become more heavy.

Mr. *Homberg* likewiſe relates, that if Quickſilver, being reduc'd to the utmoſt Fluidity by Steel and Antimony, be put over a Fire in a Glaſs, the parts of the Fire which penetrate it thro' the Glaſs, and which may therefore be deemed a Light without any additional Mixture, will change it into a Powder heavier than the Quickſilver was at firſt, and be of ſuch Proof againſt Fire, that it will bear glowing at leaſt 24 Hours without any Evaporation; and when driven with a very violent Fire, it may indeed evaporate into Smoak, but will however leave a little Parcel of itſelf behind, which being formed by this Light in the Quickſilver, will aſſume the Qualities of a ſolid and malleable Metal: This may be farther confirmed by the Experiments made on the like Occaſion by Mr. *Boyle*, by which he ſhews how ſome Bodies, ſhut up on every Side in Glaſs, become more ponderous by the Fire or Light that paſſes thro' the Pores of the ſaid Glaſs; but this is proved yet more plainly, and beyond all Diſpute, by the following Experiment of the ſaid Mr. *Homberg* in the above-mention'd Place, who having reduced four Ounces of *Regulus Martis* to Powder, placed it about the Diſtance of 1½ Foot from the true Focus of the Burning-Glaſs of the Duke of *Orleans*, ſtirring it about from time to time with an Iron Spoon; by the Heat of this Light there aſcended a great Smoak from the ſaid *Regulus* for the ſpace of an Hour, and then it ceaſed: And tho' one might expect, that by the loſs of all thoſe Particles which evaporated in Smoak, the Weight thereof would have been diminiſhed; yet on the contrary, he found that the Weight of it was increaſed 1½ quarter of an Ounce, and ſome Grains, that is to ſay, about a tenth part of the whole.

Afterwards he placed the ſame in a greater Heat, or in the real Focus, which put the *Regulus* into Fuſion, and then it weighed no more than 3½ Ounces; ſo that he reckons that this loſs of the half Ounce happening by the Evaporation and Smoaking, one may ſafely affirm, that the Light had firſt augmented it with almoſt the Weight of a whole Ounce, which by melting, and the Operation of ſuch great Heat was diſſipated again.

Now whether this laſt Calculation be juſt or not, it plainly follows from hence, that this *Regulus* had in the firſt of thoſe Experiments gained by the Rays of Light, the Weight of almoſt half an Ounce over and above all that evaporated in Smoak; which clearly ſhews, that Light can conjoyn itſelf to ſolid and palpable Bodies, and increaſe the Matter thereof.

But the Reader is deſired to conſider this as the firſt Sketch of a new Diſcovery: And I ſhall not endeavour any farther here to determine, whether we ought with thoſe great Men abovemention'd, to conſider Light as the chiefeſt and moſt active Principle in Nature. This however ſeems to be unconteſtably true, that Light is either a pure and uncompounded Fire, or carries ſuch a Matter along with it; and how much ought to be aſcribed to the Activity of Fire is ſufficiently known to every one. Experience likewiſe teacheth us, how much all Plants and Animals depend upon the Influence of the Light of the Sun; inſomuch, that if it cannot be ſaid to be the only active Principle in Nature, at leaſt it may be certainly reckon'd among the chiefeſt.

SECT. XXXVIII. *Optical Experiments paſſed over.*

I SHALL not amuſe my ſelf here to rehearſe the common and known Experiments about Light, which the Science of *Opticks* ſuggeſts as ſo many Wonders, tho' they furniſh us with one of the greateſt Proofs to demonſtrate, that there is a God who directs this miraculous Matter of Light, rendering it ſubject to ſuch Laws, notwithſtanding the amazing Velocity of its Motions, that even the greateſt Mathematicians muſt ſtand aſtoniſhed, when they ſee all that true Argumentation can deduce from it, performed by the ſame. Thus we ſee when it falls upon the Superficies of a Looking-Glaſs, that it paints the Object from whence it flows upon the ſaid Looking-Glaſs, where the Image is repreſented erect equally large, and at the ſame Diſtance as the Object: If it falls upon Spherical Convex-Glaſſes, it likewiſe makes behind the ſame a nearer and direct Image upon the Glaſs; and upon Spherical Concave-Glaſſes the Image will be ſometimes direct, ſometimes inverted, now greater, then ſmaller; one while it will appear before, another while behind the Glaſs, which may be ſhewn almoſt by Refraction in ſo many Changes thro' Convex and Concave Glaſſes.

SECT. XXXIX. *A Dark Chamber, and Convictions from thence.*

NOW if any Body would with ſmall Expence try an Experiment about the Operations of Light, let him make what they call a Dark Chamber, of which mention has been already made in *Contempl.* XII. by which means he will ſee upon a white Paper, or a piece of Linnen held in the Focus of the Glaſs that is fix'd in the Window, the Pictures of every thing that is on the outſide of the Chamber, which will produce a very pleaſing Proſpect, eſpecially if the Chamber look'd upon a Flower-Garden; for then one might ſee the Flowers in all their Colours, and Figures, painted upon the Paper, and their Motions occaſion'd by the Wind; and if there be any Men or other Creatures in the Garden, it will be a natural Moving Picture.

SECT. XL. *The Properties of the Rays of Light, with reſpect to Colours.*

BUT before we take our leave of Light, we ſhall add ſomething which ſeems to ſurpaſs even Wonder itſelf. Could any Body believe it, when he looks upon the bright and untinged Light of the Sun, that the ſame can be divided and diſtinguiſhed into ſo many different ſorts of tinged or dyed Rays, as the Great Creator has been pleaſed to communicate of capital Colours or ſimple

Tinctures, or as the Learned call them, *Homogeneal Colours?*

And yet Experience teaches the ſame, as alſo that each of theſe coloured Rays ſuffers a particular Quantity of Refraction, and that the white, or rather the clear Light, is thereby ſplit into different Parts or Kinds of Rays, which appearing ſingly, ſhew a red, yellow, green, blew and purple Colour; on which account theſe Rays are named by Sir *Iſaac Newton*, Red, Yellow, *&c.* each of 'em according to their particular Colours, foraſmuch as they are natural to them, and cannot be altered by any ſubſequent Refraction or Reflection.

Moreover, ſince all unmix'd Rays of the Sun do repreſent a certain Colour, and the whole Subſtance of Light conſiſts of the ſaid Rays, it ſeemed to be hardly poſſible, but that all theſe Tinctures jumbled together, muſt occaſion an Obſcurity to our Sight; foraſmuch as Blue, Purple, Red, and other Rays, are far ſhort of that Brightneſs which occurs to us in the pure Light of the Sun or Day; and yet we find that all theſe colour'd Rays that proceed from Light by Separation, being collected and mix'd with each other, do entirely loſe their reſpective Tinctures, and together produce a clear and tranſparent Light in all things, like that untinged Light that comes down to us from the Sun: Which new conſtituted Light may be again, as before, divided into its coloured Rays, which, if one will, being mix'd together again, ſhall the ſecond time repreſent an uncoloured Light clear and tranſparent; concerning all which, the firſt Diſcoverer, Sir *Iſaac Newton*, has treated largely in his *Opticks*.

Now I ask an unhappy Atheiſt, whether he can believe that Light has acquired theſe Properties either by Chance or ignorant Cauſes? Or whether he muſt not acknowledge, that thoſe Men argue much more juſtly, who conclude from hence, that the great and gracious Benefactor of Mankind has produced all theſe differently-colour'd Rays, to the end that the Beholder may be ſo much more agreeably affected and refreſhed with the Sight of his Creatures; and that he has placed in them the laſt Property, whereby all of 'em being mingled together do compoſe a clear and tranſparent Light, to the end that the obſcurity of the Colours may not embarraſs Human Eyes?

Beſides his Wiſdom and Beneficence muſt be acknowledged herein, that in the Parts which compoſe different colour'd Bodies, he has placed ſuch a Diſpoſition, whereby one Body when this compounded Light falls upon it, is adapted to reflect only one, or ſome particular kinds of Rays; for Inſtance one only Red, another only Yellow, a third both of 'em equally, and no other (by which a kind of a Gold-colour between Red and Yellow is generated) I ſay, to reflect theſe in a greater quantity, by which means each Body according to one or more ſorts of Rays which it reflects, either Simple or Compound, repreſents its particular Colour, and from thence is denominated Red, Yellow, *&c.*

How ſtrange ſoever this Language might have been to all former Philoſophers, yet the ſame is at preſent put out of all doubt by the afore-quoted *Opticks* of Sir *Iſaac Newton*; who tho' he may be juſtly reckoned by every Body among the moſt famous Mathematicians of the World, yet to ſet an Example to theſe leſs experienced Gentlemen, that they ſhould not too much relie upon Conjectures and Hypotheſes, has proved the ſame to be unqueſtionably true, not by Demonſtrations founded upon Arguments, but by manifold and exceeding nice Experiments. Now thoſe that have a mind to read and try the ſame, may meet with 'em in the aforeſaid Treatiſe of *Opticks*, eſpecially in the *Firſt Book*.

SECT. XLI. *The Diviſion of Light in* Iſland-Chryſtal.

BESIDES the above-mentioned Diviſions of Light, whereby it is ſplit into various coloured Rays, Mr. *Huygens* in his Treatiſe about *Light*, p. 61. and Sir *Iſaac Newton* in his *Opticks*, *Query* 25. p. 328. do ſhew us another Diviſion or Splitting of Light, which it undergoes when it meets with *Iſland-Chryſtal*; upon which as ſoon as a Ray of Light falls, it is divided into two other Rays that preſerve however the ſame Colour.

Of theſe Diviſions or Splittings of the Subſtance of Light into ſeveral other Parts, as well tinged in the firſt Caſe, as ſimple or untinged in the ſecond, I don't know that there was ever the leaſt mention made, or Track to be found among the ancient Naturaliſts; nor that this Matter has been put out of doubt ſooner than in the laſt Age by accurate Inquiries and undeniable Experiments.

SECT. XLII. *The Uſefulneſs of the Moon.*

NOW let the Reader return with us to *Tab.* XXI. *Fig.* 4. and ſuppoſe the Sun to be repreſented by A B, and the Earth by C D, in which Situation, as we have ſaid before, the Shadow of the Earth, or the pyramidal Figure C P D makes the Night, it will not be then difficult for him to fancy the great Darkneſs with which thoſe that dwell at T muſt be involved; foraſmuch as not the leaſt Ray of Light flowing from the Sun A B, can come to them directly, or in a ſtraight Line.

Now if you will pleaſe to obſerve, that the Moon M being oppoſite to the Sun A B, is at Full to thoſe that live at T, that is to ſay, they ſee its whole enlighten'd Side: You will tell us whether you can think there is any Gratitude in thoſe People that ſhall deny their great Obligations to him who has furniſhed them with this Light of the Moon in ſuch their Darkneſs.

SECT. XLIII. *Convictions from hence, and the Eclipſes.*

NOW the only Evaſion that ſuch People can make, is, that all this happens by Chance, or by neceſſary Cauſes, and conſequently that no Thankfulneſs is due: But if the Gracious Creator of the Moon had no Wiſdom, nor the Benefit which Men enjoy from the Light thereof, is not to be reckoned one of his great Views and Deſigns, how will they account for the following Particulars!

I. That the Light of the Sun has a Property when it falls upon any Bodies (as here from N, the Center of the Sun, upon M the Moon) to rebound back from it again, and to produce a reflected Ray M T; by which means thoſe that would otherwiſe remain in the midſt of the dark Cone C P D, are enlightned. Now, that without this Faculty of Light, there could be no Rays reflected from the Moon to our Earth, is plain enough.

II. Why is the Moon M, which is much ſmaller than the Globe of the Earth, placed at no greater Diſtance from it; ſo that (as we ſee in *Saturn*, and other great Planets) its Breadth and

Diameter diſappearing almoſt out of Sight, would be uncapable to communicate any Light to us that could be uſeful? And is there here no wiſe Purpoſe? And ſince the Univerſe is ſo large, why is this Place, among Millions of others, juſt choſen out, whereby it is beſt befitted to render ſuch Service to thoſe who inhabit the Earth?

III. How comes it, that the Moon is not of ſuch a Contexture as our black or dark-coloured Bodies are; by which means it would be able to give little or no Light to us?

IV. Why is it not a convex, globular and ſmooth Body, like Looking-Glaſſes and other poliſhed Things; when (as thoſe who underſtand *Opticks* know) there would be no more than one Point, or at leaſt a very little part of the Moon viſible and capable of enlightning us?

V. Why does not the Moon move according to the Line G H F S, which lies in the Plane of the Sun's way N *n*; by which means the ſame at G being oppoſite to the Sun, would never be ſeen Full, but would always be obſcured and eclipſed by the ſhadow of the Earth C P D, and on the contrary, the Moon being at F when it is dark or new, the Sun A B would be always either totally or partially covered and eclipſed thereby, at leaſt the World reaps this Benefit by the Declination of the Moon's Way M H R S from the Plane of the *Ecliptick*, or Sun's Way N *n*, or G H F S, that the Places lying near the Poles may be enlightned by the Moon, whilſt the Sun being ſtill under the Horizon, occaſions ſuch a long and diſmal Night?

And moreover, does there appear no Wiſdom therein, by which this continual Monthly Sun (as one may call it) is ſecured to the end, that Mankind may not be ſo often deprived of the Uſe thereof? How comes it then to paſs, that the

Moon's way S M H R has juſt ſuch an Obliquity with reſpect to the Plane of the Sun's Way, or G H F S, that *Firſt* the moſt part of the time that the Moon is at M, or directly oppoſite to the Sun, it is freed from the Shadow of the Earth C P D, and conſequently from its Darkneſs, and that all that part of it that is turned to us, is ſeen at Full, and in its entire Luſtre: *Secondly*, That when the Moon is at R, that is, in Conjunction with the Sun, and is ſeen at E, it is not hid from thoſe that dwell upon the Earth?

VI. But farther, ſince now the Planes of the Sun's and Moon's Way H F S G and H M S R (placed in reſpect to each other after the manner of two Hoops laid obliquely upon one another) cut each other at two Points H and S; it follows, that when the Moon is not in its own Way at M, but at H or S, it will then be in the Plane of the Sun's Way: And when it happens at the time that the Sun is not at A B, but is directly oppoſite at *a b* to the Moon at H or S, and that the Sun and the Earth are in a Right Line *n* K; it may be eaſily gather'd from the Figure, that when the Night-ſhade extends itſelf to E K T, the Moon being at H, will be thereby eclipſed and obſcured; but when it is at S, it will then hide the Sun at *a b*, and ſo cauſe a Solar Eclipſe to thoſe that dwell at S.

SECT. XLIV. *The Advantages of Eclipſes.*

BUT here ſeems an Objection to ſtand in our Way, namely, that if Light be ſo agreeable and Darkneſs ſo terrible, and if all this be ſo order'd by a wiſe Governour of the World, why do theſe *Eclipſes* or Obſcurities of the Sun or Moon come to paſs, ſince Light alone ſeems ſufficient to furniſh Man, tired by the Labours of the Day, with refreſhing Reſt?

Now to anſwer this, and to ſhew that in Eclipſes likewiſe, how dark ſoever they may be, the moſt adorable Wiſdom of God is diſplayed, we need alledge nothing more than what is already known to Aſtronomers from the Uſes thereof.

And, *Firſt*; that in the Inquiring into the Courſe of the Sun and Moon theſe viſible Signs are oft-times ſo many Evidences, whereby we may know whether what has been ſaid thereupon, in other Caſes, is well grounded or not: Of this you may meet with many Inſtances among the Aſtronomers, which we ſhall not here relate.

Secondly, They adminiſter Proofs of many natural Truths, which might not have been diſcover'd to us, without theſe Eclipſes, or at leaſt not ſo eaſily.

Thus we know that the Moon is leſs than the Sun, or even than the Earth itſelf, without any Calculation, only from hence, that (*Tab.* XX. *Fig.* 2.) the Earth's Shadow A L Z running like a Pyramid into a Point at L, is for that reaſon every where ſmaller than the Earth itſelf; or the Line H K is always ſhorter than the Diameter A Z of the Earth; and becauſe the Moon V, paſſing through this Shadow, from H to K, is not only darken'd, but even remains frequently hid a long time in the ſame; which 'tis plain would never happen, if the Moon were only of equal Magnitude with the Earth.

From whence it likewiſe follows, that the Moon in itſelf is a dark Body, at leaſt it is far ſhort of the Clearneſs of the Sun, even tho' we ſhould aſcribe to the Moon itſelf that Flame-Colour which it ſometimes ſhews in its Eclipſes, as many have thought.

From hence it alſo appears that the Moon receives its Light from the Sun; foraſmuch as when it has paſſed thro' the Earth's Shadow, and *Penumbra* after its Eclipſe, it appears again in full Luſtre as ſoon as ever the Rays of the Sun can fall upon it.

Moreover, the Eclipſes of the Sun teach us, that the Moon is not only a dark, but likewiſe an untranſparent Body, which appears by its hiding or covering the Sun.

Many ſuch Obſervations might be ſhewn from theſe Eclipſes; 'tis enough for us to have repreſented, ſome of them, by which the Benefit thereof is proved in the Examination of the Creatures.

Yet if there be any Body that is not ſufficiently convinced from hence, and it appears to him too ſmall a thing, that the Inquirers into Nature are only benefited thereby (tho' the Honour and Wiſdom of the Creator is beſt ſupported and magnified the ſame Way) yet he cannot avoid owning the great Uſe and Service thereof in other Occaſions alſo; for ſince theſe uncommon Signs of the Heavens having been obſerved by all, or at leaſt by many Men for many Ages, have been accurately noted by ſome, together with the Time when they happened; and foraſmuch as thoſe Times of the paſt Eclipſes may be likewiſe determined by Poſterity with the Help of Aſtronomical Calculations, it will eaſily appear from hence, that thoſe Eclipſes are, as it were, fix'd Land-Marks in the Series of Ages and Hiſtories; from whence again, as from an undiſputable Root of Time, a new Chronology may take its Date, and others in which there is any Uncertainty, may likewiſe be rectified thereby.

But the Uſefulneſs of the Moon's Eclipſes appears yet more particularly in determining the Longitude of the Earth; inſomuch, that the Truth of many Maps and Deſcriptions of the Earth may be examined and corrected thereby, as has oftentimes actually happened, which is not only of very great Advantage to Geographers, but likewiſe of the utmoſt Importance to ſo many Sea-faring People, whoſe Preſervation and Lives too often depend upon the Goodneſs or Badneſs of a Chart.

After having underſtood this right, it does not ſeem neceſſary to prove by more Circumſtances, that the above-mention'd Objection will fall of itſelf, and that the Eclipſes of the Sun and Moon are of great Uſe to Mankind.

Beſides, that tho' we ſhould not be able to ſhew all the Uſes thereof, yet this is no Proof of any thing's being unprofitable, ſince ſuch a Reaſon has no other Foundation than in the Ignorance of Men.

SECT. XLIV. *The Light of the Moon is without Warmth.*

BUT to proceed: Is it not a Wiſdom that has made and ruled the Moon with the Deſign of doing Good to Mankind; foraſmuch as there is hardly any Light known to us which does not warm at the ſame Time that it ſhines; and ſince the Rays of the Moon ſeems to be no other than thoſe that are tranſmitted from the Sun to it, and then reflected back to us; how comes it that the Moon-Light was neither *hot* nor *cold*, even then when the Rays thereof were collected by a great Burning-Glaſs into one Place or *Focus*, which (according to the Experiment of Dr. *Hook, Act. Lipſ.* 1707. p. 153) was 500 times ſmaller than what they filled in their natural State. Thus we ſee likewiſe in the Experiment of Mr. *La Hire*, in the *Memoirs of the Royal* French *Academy* 1705,

p. 455, that the Rays of the Full-Moon in *October*, collected in the Focus of a Burning-Glaſs of 35 Inches broad, and into a Place three hundred and ſix times leſſer than what the ſame would have filled in their natural State, did not produce the leaſt Alteration in a Thermometer which was moved by Air, and which diſcover'd the ſmalleſt Increaſe of the Warmth thereof, tho' the Ball of it was held for a while in the ſaid Focus: And we likewiſe find by the ſaid *Act. Lipſ.* 1697, p. 429, that the ſo famous Burning-Glaſſes of Mr. *Tſchirnhaus* produced indeed a greater Brightneſs by the Rays of the Moon in the Focus, but not the leaſt Warmth. Now could ever any Body have imagined that the Rays of the Sun collected by a Burning-Glaſs, or reflected from the ſame, will burn ſo terribly; and yet that the ſame Rays rebounding from the Moon to us, do not appear to bring the leaſt Warmth along with them, notwithſtanding that by this kind of Glaſſes the Brightneſs of the Moon-Light is very much augmented in the Focus as well as that of the Sun.

But we ſhall have occaſion to ſay ſomething more of this, when we come to the Contemplation of *Unknown Things*.

Now how advantagious it is to hot Countries, that this Light of the Moon produces no Heat, is obvious to every one who knows that if it was otherwiſe, and that the Rays of the Moon were likewiſe hot, that part of the Earth would be barren, and ſoon burnt up, ſince the deſcending Dews of the Night, by which it is now moiſtned, would then ceaſe to fall down, and this Fire of the Moon would draw its Vapours upwards. Moreover, if the Night-Air were not freſher and cooler, and that the Rays of the Moon kept the ſame in a continual Warmth, it is plain enough how prejudicial it would be to the Health of all Men, and the hot Parts of the World would ſuffer great Inconveniencies thereby.

SECT. XLV. *The* MOON'S *Magnitude and Diſtance from the Earth.*

I KNOW not whether it is neceſſary to ſhew in this Place, how much the Moon is ſmaller than the Earth, and how much the Light thereof (which in itſelf is hot, yet) by reaſon of the Diſtance is weaker, and leſs warm upon the Earth, than at the Moon itſelf. But ſince the preceding Figures may be of uſe to us in this Matter, and the Grounds of this Calculation depend on that of the Sun, we ſhall briefly touch upon the ſame.

1. Let A B (as before in *Tab.* XX. *Fig.* 1.) be the Semidiameter of the Earth, and D C now be that of the Moon; then will the Angle A C B of the Moon's horizontal Parallax, *when ſhe is New, or Full,* according to Sir *J. Newton,* be at a Medium.——————— 57 *Min.* 30 *Sec.*

And its apparent Diameter D C G, according to the ſame. } 31 *Min.* 30 *Sec.*

The half of which therefore for the Angle D B C, is } 15 *Min.* 45 *Sec.*

In the Fourth or laſt Quarter of the Moon, and at a middle Diſtance likewiſe from the Earth, Sir *J. N.* again ſuppoſes,

The Horizontal Parallax or the Angle A C B } 56 *Min.* 40 *Sec.*

The apparent Diameter, or the Angle D B G } 31 *Min.* 3 *Sec.*

The half of which for the Angle D B C is } 15 *Min.* 31 *Sec.*

Now ſince A and D are Right Angles, made by a *Tangent* and a Semidiameter, if we take the Earth's Semidiameter A B for an Unit, we ſhall, by plain Trigonometry, find B C, or the Moon's Diſtance from the Earth to amount to;

At *New* or *Full* barely 60 Semidiameters of the Earth.

And at the *Quarters*, barely 61 of the ſame.

So that the middle Diſtance is about $60\frac{1}{2}$ thereof.

2. Now to diſcover the Magnitude of the Moon; we firſt find its Semidiameter D C by Trigonometry aforeſaid, amounting at *Full* or *New* to $\frac{945}{3450}$ or $\frac{63}{230}$, and at the *Quarters* to $\frac{931}{3400}$ Parts of A B, or of the Earth's Semidiameter; both which do not differ much from $\frac{3}{11}$ Parts of the ſame.

From whence it therefore follows, That the Earth's Diameter A B, Is to that of the Moon C D As about 11 To 3; Conſequently the Body of the Earth Is to that of the Moon, As the Cube of 11 or 1331 To the Cube of 3 or 27, according to what we have ſaid about the Sun. And therefore 27 Globes of the Earth, are equal to 133 Globes of the Moon, or the Moon is $49\frac{8}{27}$, barely 50 times (to compute in Round Numbers) leſſer than the Earth.

This Calculation is accurate enough to build upon in Things of ſuch a Nature; and if it be not entirely exact, neither is it far ſhort of the Truth.

With this likewiſe agrees the Concluſion of that Great Aſtronomer Mr. *Flamſtead*, who makes the Diameter of the Earth (as Mr. *Whiſton* ſays in his *Prælect. Phyſic.* p. 292.) to amount to 7935 *Engliſh* Miles, and that of the Moon 2175 of the ſame; Which Proportion of 7935 to 2175, varies but little from the above-mentioned of 11 to 3.

SECT. XLVI. *Why the Light of the Moon is not Warm.*

NOW if we ſuppoſe the Point S in the Moon, and the Point B on the Earth, (*Tab.* XXI. *Fig.* 2.) and farther, the Length S *b* as the Moon's Semidiameter; and if we look back upon what has been ſaid above concerning the Diverging and Spreading of *Light* at various Diſtances, as well with reſpect to its Heat as Shining; we ſhall find that in both theſe Caſes the Force of the Light at *b*, Is to that at B, As the Square of S B, To the Square of S *b*.

Now we have ſhown above, that as S B is $60\frac{1}{2}$ Semidiameters of the Earth, or the Moon's Diſtance; ſo S *b* is $\frac{3}{11}$ parts of one Semidiameter of the Earth, when it repreſents that of the Moon.

Now $\frac{9}{121}$ is the Square of $\frac{3}{11}$ or S *b*, and $3660\frac{1}{4}$ that of $60\frac{1}{2}$ or S B; and conſequently the Firſt is to the Second, As 9 To $442890\frac{1}{4}$, or, As 1 To 49210, omitting the Fraction. From whence it appears, that the Warmth of the Light which comes down from the Moon, is about 50,000 times leſs when it has reach'd us upon the Earth B, than it is at the Point *b*, when it has proceeded no farther than the length of one Semidiameter of the Moon, or S *b*.

And this is the Reaſon, according to Mr. *Whiſton*, *Prælect. Aſtron.* p. 108. why the Light of the Moon is not attended with any ſenſible Warmth by the time it has reach'd us here upon Earth. But foraſmuch as Dr. *Hook* has collected the ſame into a Space 500 times ſmaller, and conſequently render'd it 500 times as ſtrong as the ſaid Light is in its natural State; and therefore in ſuch a Focus it is no more than 500 times weaker than at the Moon itſelf; yet, even in that caſe this Learned ed Man could not perceive any ſign of Warmth, notwithſtanding that the Shining or Light of the Moon (which deſerves to be taken notice of) was increaſed proportionably. I leave it to the Judgment and Obſervations of others, whether $\frac{1}{100}$ part of the Warmth of a hot Summers-Day with us, would be able to make any Impreſſion even on the beſt Thermometer: For that the Rays of the Sun have much the ſame Power on the Moon, as on the Earth, is plain enough from the little difference there is of both their Diſtances from the Sun.

And in this Experiment the Thermometer being moved by the Light of the Sun, it ſhould ſeem that we are obliged to ſeek for ſome other Cauſe than the ſimple Diſtance, to which we ſhould aſcribe, that the Light or Rays of the Sun are reflected to us from the Moon, without bringing any Heat along with them, but leaving it all behind them.

Be that as it will, this is plain, that if the Moon ſhould tranſmit to us ſo much Heat with its Rays, we ſhould ſuffer many Inconveniencies from thence; which is now prevented by our great Creator, who directs all Things with infinite Wiſdom and Order.

SECT. XLVII. *The Cauſe of Ebbing and Flowing not inquired into.*

NOW whether the Moon is the Cauſe of the Ebbing and Flowing of the Great Seas, and of the continual Motion of their Waves to the very bottom thereof, we ſhall neither diſpute nor inquire into here; becauſe we are not yet ſo far advanced in this Knowledge, as to be able to ſay any thing concerning it that may be free from every ones Objections, tho' we ſeem to be very far advanced in that Matter.

This is experimentally true, that the Waters in the deep and free Seas (without taking notice here of other Impediments, concurring Cauſes and Circumſtances) riſe and ſwell up to the Places, or about thoſe Places where the Moon is vertical, juſt as if they were driven thitherward by a Weight, or attracted or preſſed by ſome other Power. Concerning which may be conſulted the Writings of *Kepler*, *Newton*, *Gregory*, *Whiſton*, *Varenius*, *de Stair*, &c.

We find the ſame happens likewiſe on the oppoſite Side of the Earth; wherefore the uſual Expreſſions in which both theſe Appearances are comprehended, is, that when the Moon paſſes to the Meridian, the Water riſes; when it goes away from thence, it falls. Others ſay, that it is certain by Obſervation, that the Water is at higheſt about three Hours after the Moon has been in the Meridian. See *Newton*'s *Princip. Lib.* III. *Sect.* 24. and *Whiſton Prælect. Phyſic. Math. Sect.* 96. p. 306.

Let this Matter be as it will, it is certainly true by Experience, that if the Earth were cover'd all round with Water, it would appear Oval, by reaſon of the Swelling of the watry Surfaces on each Side; and theſe two Protuberances of Water or Mountains, as Dr. *Gregory* terms them, move continually round about the Earth, if they be not obſtructed by Land, Shoals or otherwiſe.

And as for that very ingenious Cauſe and Figure which *Deſcartes* produces, and whereby he would ſhew that it is always ebbing Water upon the Earth directly under the Moon; *Varenius* ſays in his *Geography*, *Lib.* I. *Cap.* 14. *Sect.* 11. that the ſame is contrary to Experience, and ſo it has been found.

However, leaving the Cauſe to every Man's own Opinion, this is the manner in which we muſt ſuppoſe the Motion of the Sea-Waters to happen; namely, that it is a *Swelling* and *Sinking* of the Sea, rather than a Flux or Reflux, or Ebbing and Flowing, according to the vulgar Notion thereof. See concerning the Alteration of theſe Expreſſions, *Varenius* in the ſame Place, *Sect.* 10. and *Gregory Lib.* IV. *Sect.* 65.

SECT. XLVIII. *Two Syſtems of the World.*

THERE are two Syſtems of the Heavenly Bodies, which at preſent paſs for the chiefeſt, and according to which they are ſuppoſed to be moved. The firſt ſeems to be the moſt convenient with reſpect to the annual Courſe of the Planets, and is by many taken to be the true one, on account of its Simplicity : 'Tis that which we are wont to aſcribe to *Copernicus*, who has revived the ſame from the Ancients.

They that would form a general Notion thereof, may ſuppoſe, (*Tab.* XXII. *Fig.* 1.) that the Sun ſtands ſtill, and all the principal Planets move about it, according to the Orbits which they deſcribe in this Figure. D is *Mercury*, the neareſt to the Sun; C is *Venus*, next to and without which follows the *Earth* A, which upon this occaſion is reckon'd among the Planets, and about which the *Moon* B runs; E is *Mars*, F *Jupiter*, which has four Moons moving about it, after the ſame manner as *Saturn* H has five, and it may be ſix; and both of 'em carry their reſpective Moons about with them round the Sun. Beyond all theſe are the fixed Stars A P O X.

The Second Syſtem bears the Name of *Tycho Brahé*, and ſeems in relation to the Planets, to be nothing elſe but the former a little varied in one Caſe only; and for no other Reaſon than becauſe that of *Copernicus* ſuppoſes the Earth to move about the Sun, and conſequently ſeems to contradict the Scriptures, from which *Tycho* and his Followers make a Scruple of departing.

To underſtand this Syſtem, we muſt imagine that the Earth A (*Tab.* XXII. *Fig.* 2.) ſtands ſtill, that the Moon B runs round it; that next to it the Sun S deſcribes its Courſe, and that all the Planets, with their afore-mention'd Moons, bear the ſame reſpect to the Sun, as in that of *Copernicus*: So that the Way of each of 'em ſurrounds the Sun, which continually moves about the Earth; and that all of them muſt be conſider'd as ſimply moving about the Sun. The fix'd Stars are here likewiſe repreſented by A P O X.

In both of 'em there is yet this Difference, that in that of *Copernicus* (*Tab.* XXII. *Fig.* 1.) the Sun S and the fix'd Stars A P O X, ſtanding as it were ſtill, the Globe of the Earth A really turns round its own Axis, from Weſt to Eaſt, in 24 Hours, by which means the whole viſible Firmament, Sun, Planet and Stars ſeem daily moving from Eaſt to Weſt.

In *Tycho*'s Syſtem, (*Tab.* XXII. *Fig.* 2.) nothing ſtands ſtill but the Earth A; whilſt all the above-mention'd Bodies are ſuppoſed to run round daily from Eaſt to Weſt, beſides the Courſe of each in its own Way from Weſt to Eaſt. What Reaſons may have induced other Aſtronomers to form one Syſtem from theſe two, I know not; ſince in that *Semitychonic*, the Simplicity and Convenience of the Firſt, and the Agreement of the Second with the holy Scriptures, ſeem to be, if not quite loſt, at leaſt very much alter'd; for which Reaſon we ſhall ſay nothing of this latter, neither ſhall we diſſwade any one that likes it, from embracing it, ſince we don't here undertake to diſpute the Truth thereof, but endeavour to repreſent to Sceptical Philoſophers, ſo much as we know to be true of it from Experience and unqueſtionable Calculations, in hope to convince them thereby that there is a God.

SECT. XLIX. *The Immenſurable Magnitude of the Fixed Stars.*

To come then to the Matter: Let thoſe who ſtill doubt of a Powerful and Wiſe God, lift up their Eyes with us, and ſuppoſe this to be the firſt Time of their Life that they ever ſaw the Heavens adorned with ſo many Glorious Lights; and tell us, whether they ſhould not be thereby convinced that the ſame had a Mighty Creator, and that it was not by meer Chance that they had acquired their Origin and Luſtre, no more than a Locket ſet with Diamonds, of which the moſt obdurate Atheiſt would not dare to affirm, that they were put together without the Skill of an Artificer; much leſs would they affirm it of the Heavens, eſpecially if they obſerve the immenſurable Magnitude thereof, which is ſuch, that the Aſtronomers have not been able hitherto to communicate any thing to us that can be more depended on than meer Conjecture; nor have they been able to anſwer all the Queſtions concerning the Magnitude and Diſtance of the Fixed Stars.

Thus we hear the great Obſerver of the Heavens, Mr. *Huygens*, in his *Coſmotheoros*, p. 135. ingenuouſly acknowledging the ſame in the following Expreſſions: *But thoſe who before us have endeavour'd to determine this immenſe Space, have not been able to conceive any thing certain, by reaſon of the great Exactneſs neceſſarily requiſite in the Obſervations, and which exceeded the utmoſt Care and Diligence; for which reaſon the Method I have now choſen, ſeems to be the only one remaining, in order to attain to ſomething that might be at leaſt probable in a Matter of ſuch difficult Inquiry:* Of which he gives the Reaſon a few Lines after, in this manner: *The Stars alſo of the firſt Magnitude,*

nitude, tho' view'd even by a Teleſcope, appear all ſo little, that one would take 'em for little lighted Matches without any Breadth, which is the Cauſe that no Meaſure of their Bigneſs can be found out by this ſort of Obſervation.

It will not be neceſſary to produce any other of the modern Mathematicians who are of the ſame Opinion, after the Teſtimony of an Aſtronomer, towhom the utmoſt Efforts of all the famous Men of Learning were well known, he being a Member of the *Royal* French *Academy*, and not only in himſelf a Diſcoverer of new and never before ſeen Lights and Phenomena in the Heavens, but likewiſe of an indefatigable Zeal, and abundantly bleſſed with a temporal Eſtate, whereby he was enabled to make Experiments of all Things.

The Method which that great Philoſopher took, in order to form ſome probable Conjectures concerning the Diſtance of the Stars, ſuppoſes however, that which has no certain Foundation, namely, That a Star (at leaſt one of the firſt Magnitude, ſuch as *Syrius*, or the *Great Dog-Star)* is as big as the Sun ; from whence he infers, That the Diſtance of the Stars from the Earth is 27,664 times greater than that of the Sun from the ſaid Earth : See his *Coſmotheoros*, p. 137. notwithſtanding that he allows this laſt to be above 12,000 whole Diameters of the Earth.

SECT. L. *Of the Parallax of the Fix'd Stars.*

ANOTHER Method of inquiring into this Diſtance with greater Certainty (if the Event had been favourable) has been ſince ſome Years ſet on foot by Meſſieurs *Flamſtead* and *Hook*, who thought that they could deduce from their Experiments, that the Diameter of the Earth's

Way about the Sun (according to *Copernicus*) made ſome Alteration of Sight with reſpect to the fix'd Stars, in Proportion as the Earth was ſo much nearer, or ſo much farther from them; whereby likewiſe the Syſtem of *Copernicus* of the Earth's Motion, ſeemed to be proved at the ſame time. I ſhall not here rehearſe the differing Notions of *Gregory*, *Whiſton*, and others, about the ſame; but that from theſe Obſervations, even tho' they were true, the Diſtance of the Stars and Motion of the Earth cannot be proved, is ſufficiently ſhewn by Mr. *Caſſini*, in the *Hiſtory of the* French *Academy* for the Year 1699.

So that theſe two laſt Methods, in which all imaginable Helps, known to the Moderns, are uſed, leaving the Matter ſtill uncertain, there is no great Hopes of meeting any better, at leaſt ſince the Globe of the Earth is no bigger, or (according to *Copernicus*) its Way about the Sun of a larger, that it may the better ſerve for a Foundation for ſuch an Admeaſurement. Now as long as the Diſtance of the fix'd Stars from the Sun or from the Earth remains unmeaſurable, it follows from thence, that the Magnitude of the Starry Heavens, tho' one were to conſider it as an Orb about the Sun or Earth, which cannot yet be proved from Nature, will always remain likewiſe immenſurable.

SECT. LI. *Whether the Starry Firmament be Solid or Fluid.*

NOW ſince ſuch great Mathematicians have with ſo much Ingenuity owned themſelves unable to meaſure the ſo vaſtly extended Magnitude of the Starry Heavens, which does in a manner ſurpaſs all human Imagination, how great Progreſs had there been perhaps made in the Science of

Nature, if the Philoſophers had behaved after the ſame manner, with reſpect to the Matter and Figure of which this Starry Heaven conſiſts, and if they had made the beſt uſe of that Time which young Learners employ in uncertain Conjectures and Hypotheſes, without any Foundation, in making new and material Obſervations? Since it remains a Myſtery to the greateſt Aſtronomers, how the heavenly Bodies are framed and conſtituted. *Deſcartes* ſuppoſes 'em to conſiſt of fluid *Vortices*, as is well known. Sir *Iſaac Newton*, in his *Scholium* to the 53 *Propoſition* in the Third *Book*, ſhews the contrary; and farther ſubjoins, that this Hypotheſis is inconſiſtent with all Aſtronomical Appearances; concerning which Mr. *Huygens* may likewiſe be conſulted in his *Coſmotheoros*, from p. 139 quite to the end, and in other Places; not to mention any more.

SECT. LII. *Probable Reaſons for its being Solid.*

THE Foundation of theſe Opinions, that the Heavens are a ſolid Body, is principally, That the diſtance of the Stars from each other has remain'd in a manner the ſame without any Alteration for ſo many Ages, which ſeems more agreeable to the Nature of a ſolid Matter, in which they are ſuppoſed to be placed, than in a Fluid.

THIS Concluſion ſeems likewiſe to be made with ſome kind of Probability, from the wonderful Obſervation related by Mr. *Huygens* in his *Syſt. Saturn.* p. 8 and 9, and which we don't know to have been taken notice of by any one before: His Words are as follows: " Aſtronomers place " three Stars cloſe to each other in the *Sword* " of *Orion*; and when I view'd the middlemoſt " with a Teleſcope, in the Year 1656, there ap-" peared in the Place of that one (which is no

" new thing) twelve other Stars, after the man-
" ner as they are repreſented in *Tab.* XXIII.
" *Fig.* 1. Among theſe, three that do almoſt touch
" each other, and four more beſides, appeared
" twinkling as thro' a Fogg; ſo that the Space
" about 'em ſeemed much brighter and lighter
" than the reſt of the Heavens, which appearing
" wholly blackiſh, by reaſon of the fair Weather,
" was ſeen as through a certain Opening and Se-
" paration, thro' which one had a free View into
" another Region that was more enlighten'd. I
" have often obſerved the very ſame thing with this
" without any Alteration, and in the ſame Place;
" ſo that it is likely that this Wonder, whatever
" it may be in itſelf, has been there from all
" Times; but I never took notice of any thing
" like it among the reſt of the fix'd Stars; for we
" do not find that the others, which were for-
" merly accounted cloudy (*Nebuloſæ*) nor the
" Milky-Way itſelf, have any Miſt or Vapour
" about 'em; nor if we view them with a Tele-
" ſcope do they appear to be any thing elſe than
" a Collection of many ſmall Stars.

Now I leave it to the Judgment of an impartial Perſon, whether one has not more Reaſon from theſe Experiments, to believe, that the ſtarry Heavens do rather conſiſt of a ſolid Matter, than a Flood of Particles continually moving among each other; ſince the aforeſaid enlighten'd Opening ſhews itſelf circumſcribed, after the ſame manner, which in fluid Matters, that are ſo ſuſceptible of Motion, can hardly be expected.

SECT. LIII. *The amazing Greatneſs and Diſtance of the Stars.*

Now to proceed: As this great viſible Firmament is immenſurable, on account of the almoſt inconceivable Extent of the Diſtance thereof, ſo likewiſe muſt we look upon the Remoteneſs of the Stars, and the Magnitude of thoſe Bodies, as things uncapable of being determined by Men: The Reaſon is, becauſe the Diameter of the Earth is to that of a fixed Star, As the Horizontal *Paralax* To the apparent Diameter of the ſame. Now it is plain by Experience, that the Earth, and even according to *Copernicus*, the Diameter of that whole Circle, which it makes about the Sun, muſt be conſider'd only as a Point, with reſpect to the Diſtance of the Stars; and much too ſmall to produce any Parallax. Beſides, we likewiſe find, that the beſt Teleſcopes that are made, can only repreſent the ſaid Stars as ſo many Points of Needles, and without Breadth, inſomuch that we can't diſcover any Meaſure of the apparent Diameters thereof by the Help of thoſe Inſtruments; ſo that from the Impoſſibility of obſerving the *Parallax*, and eſpecially the apparent Diameter, we are entirely diſabled from determining the Magnitude of thoſe Stars.

Now whether, with the modern Aſtronomers, we are to conſider every one of thoſe Stars, at leaſt all thoſe of the firſt Magnitude, ſuch as the *Dog-Star*, and the like, as ſo many Suns, both in Splendor and Bigneſs, has not yet been proved by any one: This is certain, that they are immeaſurably remote from us, and that in ſo unconceivable a Diſtance they derive a native Light down to us; as alſo, that if the Sun were as far from us, it would not appear bigger than one of thoſe Stars.

If therefore, without inſiſting upon a real Proof, we ſuppoſe thoſe Stars to be ſo many Suns from the Strength of their Light, and from their great Diſtance (in which we do but follow, if not all, at leaſt the greateſt Aſtronomers) we ſhall have an Idea of the Heavenly Bodies that includes in it an amazing Greatneſs.

According to this manner, the Conjectures of Mr. *Huygens* will not appear ill grounded, who, upon the Calculation laid down in his *Coſmotheoros*, p. 136, and 137. makes the Diſtance of the fix'd Stars from the Earth 27,664 times greater than that of the Sun. So that if, according to what we have ſaid before, a Cannon-Bullet will require 26 Years in paſſing from hence to the Sun, with the ſame Velocity wherewith it was diſcharged, it would require, in order to arrive at the fix'd Stars, 25 times 27,664, that is, 691,600, or almoſt Seven hundred thouſand Years; and a Ship that can ſail 50 Miles in a Day and a Night, will require 30,430,400 Years. And if we proceed farther upon this ſame Foundation, and ſuppoſe, with thoſe Gentlemen, that each Star has a Space about it proportionable to that of the Sun, I leave every Man to judge, whether he be able, without a great deal of Pains, to form to himſelf a juſt Idea of this wonderful Extent of the Univerſe, and whether he be not in danger of loſing himſelf in the Contemplation of ſo unconceivable a Greatneſs of ſo glorious a Structure, in which the Footſteps of the Divine Builder do ſo manifeſtly appear. I have choſe rather to make uſe of this Hypotheſis of Mr. *Huygens*, preferrable to others, becauſe nothing elſe is laid down by the ſame, than that one of thoſe great Stars are like the Sun, and that the Splendor and Light of the Sun, when its Diameter is contracted according to the aforeſaid manner, will be only equal to that of the *Dog-Star*; but whether this be true or no, yet it is beyond all doubt that the fix'd Stars are very great, and that their Greatneſs and Diſtance is not to be determined, ſince the manner of inquiring into it can hardly be carried farther, according to the Opinion of great Mathematicians: See *Gregory Schol. Prop.* 55. *Lib.* 3.

SECT. LIV. *Convictions from the foregoing Obſervations.*

I HAVE oftentimes moſt ſeriouſly reflected upon this Impoſſibility of determining the Magnitude and Diſtance of the Stars as an Effect of the adorable Wiſdom of their Great Creator; who knowing, that if they were capable of being meaſured, how great ſoever the Extent thereof might be, yet from the Habitude and Cuſtom of mentioning the ſame, the Wonderfulneſs thereof would be much diminiſhed: He therefore thought it neceſſary to make them immenſurable, and to put them out of the Reach of all human Endeavours, and likewiſe, to the end that thoſe who deſpiſe him might be forced in ſpight of all their kicking againſt it, to confeſs a Power to which they could ſet no Bounds; and ſince all their Learning could never fathom it, to live in a continual Aſtoniſhment at it, as it happens moſt commonly in relation to things that paſs our Underſtanding.

SECT. LV, and LVI. *The Stars Numberleſs, and Convictions from thence.*

AT leaſt the Divine Authority of the holy Scriptures is evident from hence, by which, even from the firſt Ages of the World, the Magnitude of the Stars are determined to be abſolutely inſcrutable, and conſequently ſhewn even then where the Efforts of Men in following Ages ſhould find their Bounds, notwithſtanding their utmoſt Endeavours to the contrary. The Places upon which we have our Eye on this Occaſion, are the Words of *Job*, chap. ix. ver. 9, 10. where having firſt ſaid of the fixed Stars in the 9th Verſe, *which maketh Arcturus, Orion, and Pleiades, and the Chambers of the South*, he continues in the 10th Verſe to ſay, *which doeth great things paſt finding out, yea and Wonders without number.* From whence not only what has been ſaid before, of the Inſcrutability of the Stars Magnitude may be inferr'd, but likewiſe, in order to prove the infinite Knowledge of that Spirit, by whoſe Inſpiration this Word is written, more plainly againſt all Unbelievers, we find it likewiſe litterally expreſſed, that thoſe Stars are not to be number'd, which could not have been irrefragably proved before our Times againſt any one that would have denied the ſame. Beſides the above-quoted Text, this Innumerability of the Stars has been likewiſe aſſerted in ſeveral other Places of Scripture: Thus God ſays to *Abraham*, in *Gen.* xv. 5. *Look now toward Heaven, and tell the Stars, if thou be able to number them; and he ſaid unto him, ſo ſhall thy Seed be.* And the Almighty does frequently make uſe of the ſame Compariſon to expreſs the infinite Number of *the Children of Iſrael*, viz. *Exod.* xxxii. 13. *Deut.* i. 10.—x. 22.—xxviii. 62. *Neh.* ix. 23. and ſeveral others; beſides, that theſe thouſands of *Iſraelites* are oftentimes compared likewiſe with the Sand of the Sea, as in *Iſaiah* x. 22. *Hoſea* i. 10, *&c.* from whence it appears at the ſame time, that the Number of the Stars is not only made as great, but likewiſe as innumerable as the Sands of the Sea, in the ſaid Holy Scriptures.

Now it is known to all Aſtronomers, that in order to pronounce ſuch a great Number of Stars innumerable, or to compare the Number of *Abraham*'s Children thereto, they could not be ſeen in the Heavens whilſt they had no Uſe of Teleſcopes. *Hipparchus*, in his Catalogues of Stars, has tranſmitted to Poſterity the Number of 1026; which, in our Age, has been increaſed to 1888, by the great Aſtronomer *Hevelius*; among which are to be reckon'd 950 that were known to the Ancients, 603 which he calls his, and 335 obſerved by Dr. *Halley* in the Southern Parts of the Heavens, of which Dr. *Gregory* treats more largely, *Lib.* 11. *Sect.* 29. but after that the Teleſcopes had diſcover'd that the great broad white Streak extending itſelf round the whole Heavens, and which, upon the Account of its Whiteneſs, they call the *Milky-Way*, was formed of a Collection of numberleſs little Stars, which Dr. *Halley* likewiſe teſtifies of the *Southern Magellanic Little Clouds*; See *Gregory*, *Lib.* 11. *Sect.* 22. After that, as it appears from the afore-cited Place of Mr. *Huygens*, for one Star that we ſee with our naked Eyes, ſeveral others offer themſelves to the Teleſcope; ſo that according to the Remarks of *Cherubin d'Orleans*, p. 270, and 313, by the Help of the ſame, in the only Conſtellation of *Orion* (commonly called *the Giant*) more Stars, and according to the Obſervations of *Rheita*, related by *Zahn*, Fund. 111. p. 209. twice as many ſhew themſelves, as are ſeen by the Eye only in the whole

Heavens: I ſay, ſince theſe Teleſcopical Obſervations, Aſtronomers have loſt all hopes of ever fixing the exact Number of the Stars, the rather, becauſe the more thoſe Teleſcopes are improved, the greater Number of Stars are ſeen; inſomuch, that ſome, tho' without Foundation have maintained, that the Number of the Stars is infinite, as Mr. *Huygens* witneſſes of *Jordanus Brunus* in his *Coſmotheoros*, p. 138; but to ſay nothing more than what is true, this is certain, that the modern Obſervations made by the help of theſe Inſtruments does ſufficiently evince, that the Stars are not be counted. See *Whiſton. Prælect. Aſtron.* p. 23.

Now let an Infidel tell us how it is that *Moſes* and *Job*, if they had not been Divinely inſpired, could in their Times have pronounced the Stars to be innumerable, ſince it was ſo many Ages after, that this exceſſive Multitude upon the diſcovery of Teleſcopes, has been experimentally known to Mankind.

SECT. LVII. *Whether the Stars differ in Magnitude.*

NOW if we inquire into the Opinions of the greateſt Mathematicians concerning the difference of Stars from one another, we find the moſt able of 'em ingenuouſly confeſſing, that it is perfectly unknown to them, whether all the Stars are of equal bigneſs; inſomuch that it is doubtful whether ſome of 'em appear ſmaller only upon the account of their being farther diſtant from the Eye, or whether one Star is really bigger than another.

The Apoſtle *Paul* does poſitively determine the Matter in theſe Words, 1 *Cor.* xv. 41. *One Star differeth from another Star in Glory*; and if I may be allowed to add ſomething by which that Saying of the Apoſtle ſeems to be verified in ſome manner from Nature, I deſire the Reader to conſider with himſelf, whether it be not more credible, that one Star is bigger than another, than that they ſhould all be of the ſame bigneſs, and at different Diſtances; ſince we find by the Obſervations of the greateſt Aſtronomers, that it is certain enough that ſome Stars have plainly alter'd their Magnitude, and become ſmaller: (See an account thereof in *Gregory*, *Lib.* II. *Sect.* 30.) for I cannot believe that any Body will aſcribe this only and entirely to their removing to a greater Diſtance. Yet if ſuch a thing could happen, he may be pleaſed to paſs this Reflection by, tho' otherwiſe the different Magnitude of the Planets ſeems in ſome manner to lead to ſuch an Opinion.

SECT. LVIII. *Alterations in the Fixed Stars.*

BEFORE I proceed any farther, I cannot forbear upon occaſion of what we have already mention'd, to ſay ſomething of what has been obſerved in the Heavens, with reſpect to the Stars about an Age ago, and which has aſtoniſhed all the Aſtronomers. Mr. *Whiſton* in his *Prælect. Aſtron.* p. 47. names it *a very great and aſtoniſhing Wonder, that muſt be tranſmitted or left to following Ages, without our being able to give any Solution thereof.*

That which is meant here, are thoſe Alterations among the fixed Stars, that are ſtill unintelligible to us, whereby we find that ſome new ones appear, and others that have been ſeen, do diſappear; and a third ſort ſhew themſelves one time with more and another time with a leſſer Luſtre. *Hipparchus* is ſaid to have obſerved one; but in the Year 1572, we know that a new one appeared in the *Chair* of *Caſſiopea*; in 1600 in the *Breaſt* of the *Swan*; in 1604, in the *right Heel* of the *Serpentanius*; and ſeveral others may be found in *Gregory*, *Lib.* II. *Sect.* 30. as alſo in *Mercator* and *Whiſton*, that give us an account of them and their Number. Some again, that had been ſeen before, are now inviſible; and *Hevelius* ſays, in his *Præcurſor*, that they ſought in vain for five Stars, whoſe Places however *Tycho Braché* had deſcribed full an Age before: Concerning which the ſaid *Gregory* gives us a farther account in the *Act. Lipſ.* 1691. p. 80. as alſo how a Star belonging to the *Neck* of the *Whale* has often diſappeared, and ſhewn itſelf again in the ſame Place at different times; See *Act. Lipſ.* 1703. p. 213. and how their Magnitude is remarkably changed in others, at leaſt with reſpect to their Light. The Reader may likewiſe note what has been mention'd concerning *Kirchius* in the aforeſaid *Tranſactions* of *Leipſick*, 1687. p. 647, ſince we cannot ſtand here to reckon up all thoſe Particulars.

SECT. LIX. *Concerning the Planets.*

LET us now proceed to the Planets or Wandering Stars, ſo called, becauſe they appear to us who live upon the Earth A, (*Tab.* XXII. *Fig.* 1, and 2.) to move ſometimes quick, other-times ſlow; now forwards, then backwards, and another while to ſtand ſtill for a time; which, to thoſe that have not inquired into their Courſes, looks like *Wandering*; tho' thoſe that do underſtand it, know, that with reſpect to the Sun they only proceed forwards, but yet occaſion the ſame Appearances, for which the Aſtronomers have accounted.

All the Planets, as we have ſaid before, do move about the Sun S but two, which are therefore ſtiled the loweſt, *viz.* *Mercury* D, and *Venus* C, perform their Revolution in ſuch a manner, that as they are ſeen from the Earth, they appear always on the ſame ſide with the Sun: Whereas the three other, *Mars* E, *Jupiter* F, *Saturn* H, are ſeen from the Earth A, ſometimes on the ſame ſide, and ſometimes on the oppoſite ſide of the Sun, as you may obſerve on the abovemention'd two Figures of this Table.

Now in order to form a right Notion of theſe Planets, we muſt again endeavour to diveſt our ſelves of thoſe Prejudices which we have ſuck'd in as it were with our Mother's Milk, and by which we are taught to imagine, that theſe great Bodies are about the ſize of the Marbles we play'd with when we were Children, or ſomewhat leſs, and that they are but a very ſmall Diſtance from us; and we are yet the more confirmed in the ſame, by the Figures that Aſtronomers are wont to give us of theſe Planets, which at the beſt do repreſent to us the Proportion of their Diſtances, but in a very ſmall Compaſs, and do rarely or never ſhew us their Bodies in compariſon of their real Magnitudes, which likewiſe conſiderably helps to prevent our Conceptions thereof.

SECT. LX. *The Magnitude of the Planets.*

THAT famous Aſtronomer Mr. *Huygens*, in order to improve our Notions concerning the Planets, did at the latter end of his Life draw their Magnitudes in a particular Figure in proportion to that of the Sun, which we have therefore transferr'd from his *Autom. Planet.* to our *Tab.* XXIII. *Fig.* 2. where the Earth A, and the Moon by it at B, and ſo the reſt of the Planets are repreſented in their proportionable Bigneſſes with reſpect to the Sun G D K. According to his Obſervations we find the Diameter of the Sun to be,

110 times greater than that of the *Earth* A.
308 ———— ——than that of *Mercury* D.
84 ———————- -than that of *Venus* C.
166 ————- - — —-than that of *Mars* E
$5\frac{1}{2}$ ——— ———than that of *Jupiter* F.
$3\frac{4}{21}$———— -—— than that of *Saturn's Ring* G I.

and that of the Ring $2\frac{1}{4}$ times bigger than the Diameter of the Globe of *Saturn* H.

From whence it follows, if theſe Planets are compared with the Earth, which is beſt known to us,

I. That the *Earth* is not quite 3 times ſo thick, and conſequently not quite 27 times as big as the Planet *Mercury* D.

II. That *Venus* C is about $1\frac{1}{3}$ as thick, and conſequently as big as the Earth itſelf.

III. That *Mars* E, is ſmaller than the Earth, ſo that the Diameter of the latter will make 1^{1} of the former, and conſequently contains $3\frac{3}{8}$ as much Matter as the Globe of *Mars*.

IV. That *Jupiter* F, has 20 times as great a Diameter, and 8000 times as large a Bulk as that of the Earth.

It has likewiſe four Satellites or Moons about it, each of which does not ſeem leſſer than the whole Earth: See *Huygens Coſm.* p. 101.

V. After theſe come *Saturn* H, which, what no Body could ever have thought or ſuſpected, is ſurrounded with a Ring G I, that is flat and very thin in proportion to its Magnitude: There is a Space between that Ring and the Body of the Planet, which it encompaſſes without any Contiguity like a Vault or Ceiling; for which reaſon this Diſpoſition of *Saturn* with its Ring, being viewed from different parts of the Earth, is wont to repreſent a very different Figure. The Diameter of this Ring G I, is according to the foregoing Computation about 30 times as large as the Diameter of the Earth, and therefore if it were a Globe, it would contain about 27,000 times the quantity of this Globe of the Earth.

The Diameter of *Saturn* itſelf is about 13 times as big as the Earth's, and conſequently the Body of that Planet is 2197 times as large as the whole Earth; beſides which there are five Moons that are obſerved to circulate about the ſaid Planet and its Ring.

SECT. LXI. *The Times of the Planet's Revolutions and Diſtances from the Sun.*

NOW the Times in which theſe Planets finiſh their reſpective Circulations about the Sun, have been obſerved as follows: That of *Mercury*, in three Months; of *Venus*, in about 7½ Months; of *Mars*, in almoſt two Years; of *Jupiter* in 12 Years; and that of *Saturn*, in about 30 Years, all of 'em computed as near as may be.

We ſhall here paſs by the *Satellites*; they who deſire to know the Time of their Revolutions about *Jupiter* and *Saturn*, may conſult the Aſtronomers.

The Diſtances of theſe Planets from the Sun are likewiſe reckoned in the following manner: Upon the ſuppoſition that the Diſtance of the Earth from the Sun is 10, that of *Mercury* is hardly 4, *Venus* 7, *Mars* 15, *Jupiter* 51, and *Saturn* 95 of the ſame Parts: See *Gregory Aſtron. Lib.* I. *Sect.* 1. So that the Diſtance of our Earth from the Sun being, according to *Caſſini* and *Flamſtead* (for the more convenient Calculation) 10000 Diameters of the Earth; *Mercury* will be 4000; *Venus* 7000; *Mars* 15000; *Jupiter* 51000; and *Saturn* 95000; and proportionably ſo much greater if with Mr. *Huygens* we account the Diſtance of the Sun to be 12000, or with Mr. *la Hire* 17000 of the ſaid Diameters. We have here uſed the ſmalleſt Numbers, becauſe we would proceed with the greater Certainty.

SECT. LXII. *The Velocity of* Venus *and* Jupiter.

NOW let the Atheiſt conſider, that notwithſtanding the contemptible Notions he has of theſe Heavenly Bodies, which he looks upon as no bigger than they are repreſented in *Tab.* XXII. *Fig.* 1, and 2; and in *Tab.* XXIII. *Fig.* 2. yet *Venus*, the Evening and Morning Star, is a Globe not much ſmaller than that of the Earth; and, which is amazing, it moves about the Sun with a Swiftneſs, 146 times greater than that of a Bullet, ſhot out of a Cannon. To give likewiſe an Inſtance of one of the remoteſt Planets, let him contemplate that of *Jupiter*, which is a Globe 8000 times as big as this of the Earth; and let him conſider, *Firſt*, how great a Diſtance it muſt be from him, when ſo vaſt a Body ſhall appear as ſmall as one of our Childrens Marbles: And *Secondly*, what a Force is neceſſary to move ſuch a prodigious Globe along the Heavens, the Motion of which we find to be 54 times ſwifter than a Cannon-bullet's.

SECT. LXIII. *The Calculation of the Revolutions of the aforeſaid Planets.*

THIS may perhaps ſeem ſomewhat whimſical and incredible too to ignorant Perſons; but thoſe who underſtand Aſtronomy know that nothing need be advanced by Conjecture or Gueſſing, when one compares the Magnitude and Diſtance of the Planets with that of the Sun; but that the ſame may be deduced by certain Conſequences from the Obſervations that have been made concerning them, as every Mathematician knows, and as literally appears in the *Syſt. Saturn.* p. 77 and 81, of Mr. *Huygens*; ſo that upon the whole Matter, it depends only on the Greatneſs and Diſtance of the Earth with reſpect to the Sun, not to know the Proportion only, but the true Meaſure thereof, of which Aſtronomers are in a manner ſo much Maſters, that they can be ſure that neither the Planets themſelves nor their Diſtances are ſuppoſed too great.

If it be then known that there is no Miſtake of any Importance made herein, the ſwiftneſs of their Motion may be eaſily computed from the time of their Revolution: As for Inſtance, a Cannon-bullet runs, according to the Experiments of *Merſennus*, (quoted by *Huygens* in his *Coſmotheoros*, p. 125) 100 *French Toiſes* of ſix Foot, in the ſpace of a Second; and according to the moſt accurate Admeaſurement of the *French*, the Diameter of the Earth amounts to 6,538,594 of the ſaid *Toiſes* or Fathoms,

Accordingly then a Cannon-Bullet would run the length of the Earth's Diameter in about 65,386 Seconds, that is, full 18 Hours; from whence it follows, that it would run in one Year, conſiſting of 365 Days, 486 of the like Diameters, and 40 thereof in a Month of 30 Days.

Now it appears above, that (*Tab.* XXII. *Fig.* 1, and 2.) the length between the Sun and Earth, or the Line A S, being ſuppoſed to be 10,000 Diameters (which is leſs than what is allowed by Meſſ. *Huygens* and *la Hire*) the Diſtance of *Venus* from the Sun, or the Line S C, will amount to 7000 of the ſaid Diameters; and if now we take the Revolution C I R for a Circle, of which C S is the half Diameter, the whole one C R will be 14000 of the Earth's Diameters; and ſuppoſing the *Ratio* of the whole Diameter to the Circumference of a Circle, according to what is known, As 113 To 355; the Circumference CIR of this Diameter C R, which *Venus* finiſhes in $7\frac{1}{2}$ Months, will be 43,982 Diameters of the Earth.

But it is found before, That a Bullet runs 300 of the like Diameters in $7\frac{1}{2}$ Months, or in the Time of *Venus*'s Revolution. Thus it appears, that the Velocity of *Venus*, with reſpect to that of a Cannon-Bullet is, As 43,982 To 300 or; that *Venus* moves 146 times faſter than the ſaid Bullet.

After the like manner, and with very little Trouble too, we may compute, that ſince *Jupiter*'s Diſtance from the Sun, or the Semidiameter of its Way (ſuppoſing it likewiſe to be exactly circular) amounts to 51,000 Diameters of the Earth, and that the Time of its Revolution is 12 Years; it moves about 55 times, at leaſt a good deal above 54, faſter than a Cannon-Bullet, that ſhall run in one Year 486 of the like Diameters, as has been ſhewn above. We ſuppoſe here the Courſes of the Planets to be uniform, tho' Aſtronomers find that they move one while faſter and another ſlower; but foraſmuch as they perform their Revolutions in about the ſaid Time, this Calculation is ſure enough.

SECT. LXIV. *The Swiftneſs of one of* Jupiter's *Moons.*

IF we now ſuppoſe with Mr. *Caſſini*, (See the *Coſmotheoros*, p. 101) that the neareſt of *Jupiter*'s Moons is diſtant from it $2\frac{5}{6}$ Diameters of that Planet, and that its Revolution is performed in one Day, eighteen Hours, twenty eight Minutes, and thirty ſix Seconds; the whole Diameter of the ſaid Revolution, will be $5\frac{2}{3}$, and the Circumference, ſuppoſing it to be exactly circular, will be $17\frac{272}{339}$ Diameters of *Jupiter*.

Now one Diameter of *Jupiter* is equal to 20 Diameters of the Earth; the Revolution therefore of this neareſt Moon is 356 of the ſaid Diameters, and according to the ſuppoſed Time of the Revolution this runs in one Day in its Way about *Jupiter*, 201 Diameters of the Earth; and *Jupiter*, according to its before-ſuppoſed Diſtance and Time of its Revolution runs 73 Diameters in its Orbit about the Sun in the ſaid Space of a Day; ſo that this Moon runs in its Orbit about twice or thrice as faſt as *Jupiter* itſelf, and conſequently a great deal above 100 times faſter than a Cannon-Bullet, tho' it be as big as the Earth itſelf: See *Huygens*'s *Coſmotheoros*, p. 101.

SECT. LXV. *The amazing Force that is requiſite to move* Jupiter.

NOW if one would form an Idea of the amazing Greatneſs of that Power by which the ſaid Planet is moved, it having been proved before, that the Diameter of *Jupiter* is 20 times greater than that of the Earth, it follows that the former Planet is 8000 times bigger than the latter.

Now thoſe who underſtand Mechanicks know, that by multiplying the Maſs of two Bodies, each of 'em by its own Velocity, the Proportion of the Powers that move them, may be learned from thence: Suppoſing then that the Earth's Magnitude to be as an Unit, and the Velocity of the Cannon-Bullet to be likewiſe as an Unit, the Force that muſt move the Earth with the ſame Swiftneſs as a Cannon-Bullet is moved, muſt alſo be as an Unit, becauſe an Unit multiplied by itſelf produces only an Unit.

And in this Compariſon the Globe of *Jupiter* muſt be ſuppoſed as 8000, and its Velocity as 54; becauſe it moves in its Orbit 54 times ſwifter than a Bullet; which being multiplied with the other, gives 432,000 for the Force that moves *Jupiter*. So that it is irrefragably proved hereby, that the Force which moves *Jupiter*, and conſequently the Strength of that Planet it ſelf is at leaſt 432,000 times as great as that which is capable of cauſing the Earth to move with the ſame Velocity as a Bullet is diſcharged from a Cannon.

We ſuppoſe here the Denſity of the Parts of which the Earth and *Jupiter* are compoſed to be equal; tho' ſome reckon that of the Earth to be greater than *Jupiter*'s; yet this difference will not hinder the ſaid Number from remaining a great many thouſands of Times more; but this is not the Place to make ſo nice an Enquiry in.

SECT. LXVI. *Convictions from the Whole.*

NOW they that hitherto doubt whether there be a mighty Creator and Director of this Univerſe, let them ſit down by themſelves, and ſeriouſly conſider, *Firſt*, How theſe Planetary Globes, ſo amazing in their Magnitudes, are whirl'd about the Sun with ſo dreadful a Velocity, ſo far ſurpaſſing the almoſt unconceivable Motion of a Cannon-Bullet.

Secondly, How other Planets, or Moons, each of which will hardly yield in Magnitude to the Earth, are carried with a yet greater Swiftneſs about the aforeſaid Planets.

Thirdly, That neither the Motion of *Jupiter* in his Orbit, nor of the reſt of the Planets, can be performed but by a Force ſo many thouſand times greater than that mighty Strength by which a Globe as large as the whole Earth is driven with the ſame Velocity as a Bullet ſhot out of a Cannon.

And if this laſt Force, whereby the Earth can be ſo ſwiftly moved, ſurpaſſes all human Conception, what ſhall we ſay of that which moves the Planet *Jupiter* in the Heavens?

SECT. LXVII. *The Evaſions of Atheiſts, and their Pretences.*

I KNOW very well, that in order to elude the Proof of an All-ruling God, which is ſo terrible to Atheiſts, thoſe miſerable Wretches are wont to conceive the Motions of theſe vaſt heavenly Globes, as they were ſo many round little Balls, floating and circulating in a Veſſel of Water, which happens when the Water is put into a Circular Motion; and they are not a little confirmed in ſuch Fancies, by the Figures with which Aſtronomers are uſed to repreſent the Structure of the World, as may be ſeen in *Tab.* XXII. *Fig.* 1, and 2. where we find the Revolutions of the Planets repreſented like the forementioned Balls in Water, upon one and the ſame Plane; inſomuch that there does not ſeem to be wanting any other Direction for their Motions than only conceiving a circular Motion of the Matter in which they ſwim, and the rather, becauſe if one moves the Water in a round Veſſel ſwiftly about with a Stick, we may often obſerve ſome of the little Particles thereof whirling about their own Axis, and at the ſame time carried about the common Center; from whence they infer, That the Moons alſo of *Saturn* and *Jupiter* may be likewiſe carried about their reſpective Planets, as here at F and H, without any particular Direction.

And thus theſe deplorable Diſputers are uſed to contemplate, and to account for the Wonders produced in the Heavens, without conſidering them otherwiſe than as very different Figures and Reſemblances; and to make their Opinions paſs with greater Appearance of Truth, they uſe thoſe ſhallow Maxims of ſome Philoſophers, That the moſt ſimple Hypotheſis or Notions that People form of things, are always the trueſt, which being eaſily agreed to by the Ignorant, and thoſe who endeavour to evade the Labour of a juſt Inquiry, ſatisfies them the better, and procures them the more Diſciples.

But in caſe things happen'd after ſuch a manner, yet from the Motion of this Matter that runs round, (if there be any ſuch Matter) an over-ruling Power of the great Director may be clearly enough demonſtrated; ſince Experience teaches (as ſhall be more fully proved by and by) that all ſimple Motions are perform'd in Right Lines, and that Bodies can by no means deſcribe Circular ones without ſome particular Direction.

SECT. LXVIII. *Thoſe Evaſions anſwer'd*; Firſt, *By the Orbs in which the Planets move.*

BUT now when we turn away from this fictitious Heaven, which has no other Foundation but in the Fancy of thoſe who only make uſe of it, that they may more conveniently (or according to them, more ſimply) form an Hypotheſis for the Appearances that are moſt obvious to them; and if we further apply our Contemplations, without any Prejudices, to thoſe things which the true Inquirers have diſcover'd by their Obſervations, about the Motions of the Planets, it may be concluded, and not obſcurely, by every one, that the former Evaſions are groundleſs: For, *Firſt*, All theſe great Globes are far from being moved in one and the ſame Plane, as they are truly repreſented in *Tab.* XXII. *Fig.* 1, and 2. tho' it be according to the common Manner, even of the greateſt Aſtronomers; and we find that all of them cut thro' their Planes, the one the others, like two Hoops placed obliquely in each other. For inſtance, let the Plane of the Paper upon which is drawn the third Figure in *Tab.* XXII. be the Plane in which the Sun revolves about the Earth (or the Earth about the Sun, for we do not diſpute that Matter here) and let the Oval Figure E A F B, be in this ſame Plane; then let us farther ſuppoſe, that the ſecond Oval A C B D to be ſo placed, that the Part A C B be above, and the other part A D C under the Plane of the firſt Circle; ſo that theſe two Planes, like the two aboveſaid Hoops, have nothing common to each other, but one only Right Line A S B. If then we take this laſt A C B D, for the Way of any Planet, we ſhall perceive how it differs from the Plane of the *Ecliptick*, that is, from the Sun's or Earth's Way, and makes an Obliquity upon the ſame, ſo that there remains, between both the Planes, a Width, or Breadth, on the one Side as C F, and on the other of D E.

SECT. LXIX. *The Properties thereof.*

Now to form a fuller and truer Notion of the Planets Orbits, we muſt lay down ſome Concluſions which are known and agreed to by all Aſtronomers, namely, That,

Firſt, The Way or Orbit of each Planet is in a particular Plane, and peculiar to itſelf, ſo that at one Time it is at C above, and another Time at D, under the Plane A E F B of the *Ecliptick*.

Secondly, That even the Moons of *Saturn* and *Jupiter* don't move in the ſame Plane in the which the Orbit of their Planet, or likewiſe the *Ecliptick* lies; but that they decline from both, and according to the moſt accurate Obſervation, compleat their Courſe in a particular Plane. See *Whiſton*'s *Prælect. Aſtron.* p. 201. where he reckons up their Appearances.

Thirdly, That each of theſe particular Planes, in which the Planets move, do never interſect the Plane of the Sun's Way in the ſame, but all in different Lines: So that, for inſtance, if *Mars* does it in the Line A B, *Jupiter* will do it in the Line R T, *&c.* See *Whiſton*'s *Prælect. Aſtron.* p. 191.

Fourthly, That even the Obliquities or Angles which the Planes of the Planets Orbits make with the Ecliptick, do not agree in any two ſo as to be the ſame, but are different in all of them: They who deſire to know the Occaſion and Meaſure of theſe ſeveral Interſections and Obliquities of the Planes, (called by the Aſtronomers *Lineæ Nodorum & Inclinationes)* ſuch as A B, T R, and C F, E D, may meet with 'em, in the *Automaton.* of Mr. *Huygens*, p. 447. and elſewhere.

Fifthly and *Laſtly*, We are to know, That all theſe interſecting Lines A B, T R, *&c.* tho' they all of 'em differ, yet each of 'em paſs through the Sun S; ſo that that Luminary ſhines upon the Interſections of all the Planes of the Planets Ways.

SECT. LXX. *The Atheiſts Evaſions Anſwer'd;* Secondly, *By the Planets continual Approach to the Sun.*

Now if what has been already ſaid, concerning the wiſe and wonderful Direction of the Planets Motion, be not ſufficient to convince the moſt obdurate Atheiſt, a gracious God has been further pleaſed to repreſent and manifeſt to the Sight of every one, ſomething in the Courſe of theſe heavenly Bodies that ſeems to put beyond all Diſpute the Greatneſs of that Power which rules and directs them, and to reduce the Matter to an entire Degree of Certainty. In order to prove this, we affirm, and no body can deny it, that it is experimentally true, That all Bodies, when put into Motion, do proceed in a Right Line, unleſs ſome other Cauſe or Power obliges them to recede from it; and it is known, that a Stone A moved circularly in a Sling about a Point S (*Tab.* XXII. *Fig.* 4.) in the Circle A H D E, with ſuch a Swiftneſs, that it cannot be brought down by the Force of its Gravity when it is at A, will not continue to move in the ſame Circle towards H, as ſoon as the ſaid Sling is looſe, and the Stone left to it ſelf, but purſue its Way according to the Right Line A F, which touches the Circle at A; and this happens not only in a Circle, but in all other Curve Lines, as Experience teaches us.

Now let the beſt Philoſopher tell us, how it comes to paſs, that ſuch great Bodies as theſe Planets are, moving about the Sun with a Swiftneſs ſo much greater than that of a Cannon-Bullet, and with ſo prodigious a Force as has been ſhewn above, do not likewiſe obey this Law and run always in a ſtrait Line, but deſcribe inceſſantly

a Curve

a Curve Line, and always return to the Point from whence they began; and how theſe moved Bodies are compelled every Minute to depart from their Right Line, and deſcribe by their Courſe the Orbit which they do.

For that the Planet A (*Tab.* XXII. *Fig.* 5.) being moved about the Sun in the Curve Line A E D Z, when it is at A endeavours to go to F, according to the Tangent A P, and when at G tends to I, along another Tangent G Q, as is diſputed by no body. Tell us then the Reaſon why ſuch a great and ſwift Globe, certainly tending from A to F and from G to I, is continually protruded or attracted to the Sun, or at leaſt is brought nearer to it; ſo that A F and G I, being the Lengths which the ſaid Planet is to run at each Place, in the following Minute, in the Tangent Lines A P and G Q, it is forced to forſake them, and, in the very ſame Inſtant, to approach ſo much nearer to the Sun, as the Lines F G and I H are in Length; without which it would not be poſſible that this Planet could continue in its Curve Way A E D C about the Sun?

This is not to be anſwer'd by the Hypotheſis which ſome Philoſophers have hitherto maintaind, That the Sun has a Vortex of a ſubtile Matter about it, which running round, drags the Bodies of theſe Planets along its Stream; foraſmuch as the Gravity thereof remains the ſame; therefore they are bound to ſhew why that Matter it ſelf deſcribes a Curve Line, and does not, like other things, move directly according to Tangents; ſo that here likewiſe we muſt have recourſe to a Power that governs the Motion of this Matter; but the famous Mathematician Sir *Iſaac Newton*, and others, have ſhewn, that we ſeek in vain the Properties of this Circular Motion in the Matter of the Vortices.

SECT.

SECT. LXXI. Thirdly, *By the Courſe of the Planets in an Ellipſis.*

BUT to cut off all Cavilling about this Difference, it may be ſufficiently proved from the Property of the Curve Lines, according to which each of theſe Planets are moved, that there muſt be an inceſſantly directing Power that regulates their Courſes, and that they cannot alone be carried forwards by any circularly moving Matter.

For the continual Experience of all Aſtronomers that have ſucceeded the Great *Kepler*, and ſo frequently repeated Obſervations, have put it ſufficiently out of all doubt, that the Planets are not moved in exact Circular Figures; in which Caſe it might be ſuppoſed, with ſome appearance of Truth, that there is ſuch a whirling Matter, but they are Curve Lines of quite another Property than Circles, and appear by manifold Obſervations to be *Ellipſes*, or oval Figures, as you ſee in *Tab.* XXII. *Fig.* 5. A E D Z.

In theſe *Ellipſes*, as is well known to the Mathematicians, there are two Points K and S, each of which they call a *Focus*, or *Point of Burning*, from whence the ſame may be deſcribed by a String K E S, faſten'd at K and S, and by a Nail at E, which being directed by the String, deſcribes the Circumference E D Z A, as is known to Carpenters, Joiners, and other Mechanicks.

In one of theſe *Foci* is plac'd the Sun S, about which the Planet is continually moving; A is the remoteſt, and D the neareſt Point of the Orbit to the Sun; for which Reaſon likewiſe, A the fartheſt, and D the neareſt Point to the Sun, are termed by Aſtronomers, the *Apherlium* and *Perhelium.*

SECT. LXXII. Fourthly, *Becauſe their remoteſt Points extend to different Parts of the Heavens.*

AND that no body may imagine neither, that any ignorant Laws of Nature have any Place here in a Stream of *Vortices*, or whirling Matter; the adorable Creator, who alone will be acknowledged and glorified herein, has ſhewn, with irrefragable Proofs, his abſolute Empire over theſe great Bodies, and likewiſe his wonderful Power in thoſe vaſt and remote Spaces; for which Purpoſe he has not thought fit that the *Elliptical* Orbits of the Planets, as A E D Z, and L R, M T, (which very much differ in Magnitude and Diſtance from the Sun) ſhould have their *Aphelia* A and L extended from the Sun S to one and the ſame Place of the Heavens, as B; which would have appeared more convenient to our Conceptions, and might have been uſed as a Principle to diſcover, after this manner, a general Law of Nature, whereby we could have accounted for theſe Motions and Diſpoſitions in the Heavens.

But to the End that every one who contemplates theſe great Works might be certain, on the contrary, that it is only the irreſiſtable Will of a ſupream Director of all things that has place in this Matter, he has ſo order'd the Orbits of the Planets A and Y, namely, A E D Z and YVNW, for ſo many Ages, that the one ſeems to be entirely independant of the other; placing not only each of them in a different Plane obliquely upon the other, as we have ſhewn above, but likewiſe cauſing all the Lines proceeding from the Sun S, thro' the *Aphelia* or remoteſt Points A and Y, to tend to different Parts of the Heavens, as B and C, altho' the ſaid Sun S, with reſpect to which only he has made them, does ſufficiently appear in the one Focus of all theſe *Ellipſes:* The Truth of this may be ſeen in all the Books of the Aſtronomers, and particularly the Places of the *Aphelia* of each in the *Automaton.* of Mr. *Huygens*, p. 441.

SECT. LXXIII. *Convictions from thence.*

Now after having well conceived all this, thoſe who think it concerns them to learn God from his wonderful Works will be pleaſed to uſe their Endeavours, firſt, by what has been ſaid, to make a true Notion of the Planetary Heavens familiar to them, and comparing one thing with another, to conſider whether a Man argues without Foundation, who maintains, that the Power and Wiſdom of the Great Creator ſhines out more brightly here than the Skill and Contrivance of the Workman in the moſt curious Clock, or any other Machine whatſoever.

For, *Firſt*, conſidering the almoſt unconceivable Magnitude of theſe wandering Globes, and their Diſtances from the Sun, which may only and eaſily be determined by the Diameters of the Earth. And, *Secondly*, ſeeing that *Saturn*, tho' it be diſtant from the Sun at leaſt 100,000 of the ſaid Diameters, according to the lateſt Obſervations, between every two following Points of its Orbit, is always attracted towards the Sun, notwithſtanding there is not the leaſt Band or Connexion between the one Body and the other. *Thirdly*, Finding that theſe Approaches to the Sun have place in all the Planets, tho' there is likewiſe no Union between any of them. *Fourthly*, Knowing that each of 'em performs its Courſe in a particular Plane. *Fifthly*, That they deſcribe no Circles which we ſee generated in natural Motions, after different Manners, but to ſhew that a particular Direction obtains here, they move in *Ellipſes*, or oval Figures, every whery preſerving their Geometrical Properties. *Sixthly*, That theſe oval Figures are each of 'em extended lengthwiſe to a different Place in the ſtarry Heavens. *Seventhly*, That their Motions have continued for many Ages in this Order, without any Confuſion among each other. And, *Finally*, ſince no body, who underſtands it right, can, without Amazement, obſerve, That theſe Globes of ſuch an amazing Magnitude (that *Jupiter* is at leaſt 8000 times bigger than the Earth, and the reſt, excepting *Mercury* and *Mars*, which are ſomewhat ſmaller) are either as big, or bigger, than the Earth itſelf, and yet all of 'em move about the Sun with ſo prodigious a Swiftneſs, as far exceeds that of a Cannon-Bullet.

SECT. LXXIV. *The Motion of the Planets about the Sun.*

Now if we reflect upon the Experiments which, beſides the foregoing, have been made by the modern Aſtronomers, and would be too tedious to be related here, new Wonders would occur to us at every Turn, and always adminiſter freſh Occaſion of acknowledging a tremendous Power, and a Direction continually exerting itſelf.

To ſay nothing therefore of the Comets, and their Courſes from and to ſo many different Places of this immenſurable Space, ſince neither their Cauſes, nor the Ends for which they have been made, do yet fully appear to us: Let us once again bring before our Imagination thoſe great Celeſtial Globes, the Planets, and conſider, that in that incomprehenſible Motion with which they circulate about the Sun in their Orbits, they likewiſe revolve or turn upon their own Axes from Weſt to Eaſt, at leaſt it has been viſibly obſerved already in *Jupiter*, *Mars* and *Venus*, and even in the Sun itſelf.

Thus we find (to ſay nothing of the Earth, ſince all Aſtronomers do not agree therein) that that dreadful Globe of Fire, the Sun, turns round upon its own Axis in 25 Days; *Venus* in 23; *Mars* in $24\frac{2}{3}$; and the great Globe of *Jupiter* in 10 Hours. See *Gregory's Aſtronom.* p. 36. As for the reſt, we have not yet been able to diſcover any thing certain about them.

And in order to convince every one of the Dreadfulneſs of the Powers which exert themſelves in this Matter, we need only inveſtigate the Swiftneſs wherewith theſe great Globes are carried about their reſpective Axes after the following ſimple Manner.

For ſuppoſing the Earth's Diameter to be 6,538,594 *French Toiſes* or Fathoms long, the Circumference thereof will contain 23,541,600 of the ſame, ſince the Diameter of a Circle Is to its Circumference, As 7 To 22, or yet nearer, As 113 To 355.

Now each Point that is upon the middle Superficies of the Earth would run ſo many Fathoms in 24 Hours, and conſequently $237\frac{3}{4}$ in one Second of an Hour.

But a Cannon-Bullet (as has been ſhewn above) runs 100 of the like Fathoms in a Second.

Conſequently every Point upon the Equator of the Earth revolves with much more than twice the Swiftneſs of a Cannon-Bullet.

If then, according to this Proportion, the Velocity in the Revolutions of the other Planets be meaſured, and if it be ſuppoſed (to ſpeak within compaſs) that the Diameter, and for the ſame Reaſon the Circumference of the Sun, is but

100 times bigger than that of the Earth, we ſhall find, that ſince it employs 25 Days in one Revolution about its own Axis, it turns four times as ſwift as the Earth, and each Point in its Equator conſequently is moved 8 or 9 times as faſt as a Cannon-Bullet.

So likewiſe *Jupiter*, which is 20 times as big as the Earth, and revolves in the ſpace of ten Hours, would carry every Point in its Equator 20 times as faſt about its Axis as thoſe of the Earth; ſuppoſing that this Planet ſhould likewiſe require 24 Hours for that Purpoſe; but as it performs the ſame in 10 Hours, its Velocity will be yet $2\frac{2}{5}$ times greater, or *Jupiter* will revolve 48 times ſwifter than the Earth, and each of the aforeſaid Points move above 100 times faſter than a Cannon-Bullet.

SECT. LXXV. *The Velocity of* Saturn, *and of his Ring.*

LET us moreover caſt our Eyes upon *Tab.* XXIII. *Fig.* 2. or the Repreſentation of *Saturn* A, and its Ring G I, and conſider, that this Globe H is about 2000 times bigger than the Earth, and that the Ring G I is full 4 times as broad as the Globe of the Earth is thick, and that the Space likewiſe between the ſaid Ring and the Body of that Planet is not leſs in its Breadth. Again, that this Ring is thin and flat, and no way adheres to *Saturn*, but is quite looſe round about, as has been hinted above; yet that this Ring never forſakes nor ſtays behind *Saturn* in its Motion, but always accompanies it with equal Velocity, and has done ſo for many thouſand Years, notwithſtanding that that Globe moves about 20 times as faſt as a Cannon-Bullet, as may be eaſily computed after the abovemention'd Manner.

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TAB. XX.

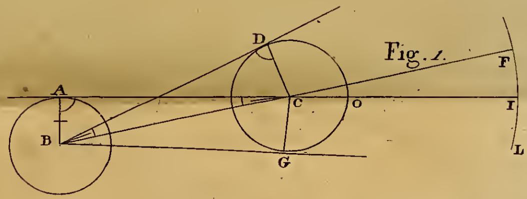
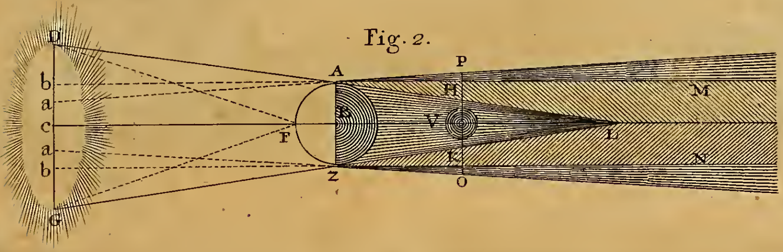


Fig. 1.

Fig. 2.



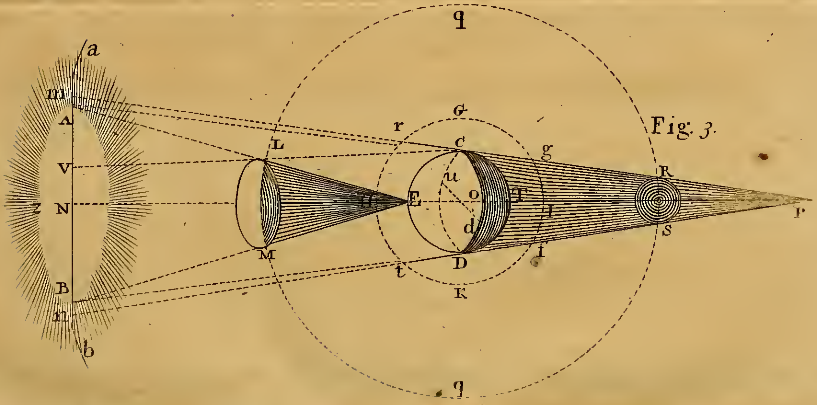


Fig. 3.

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TAB. XXI.

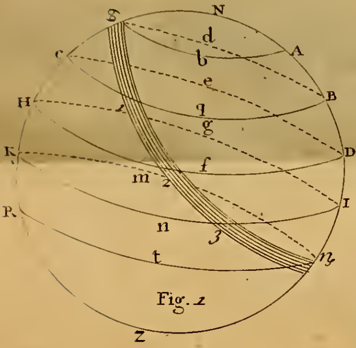


Fig. 1

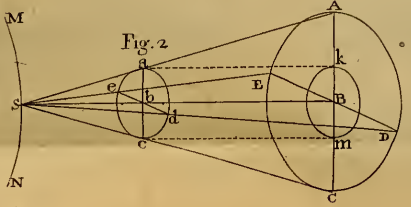


Fig. 2

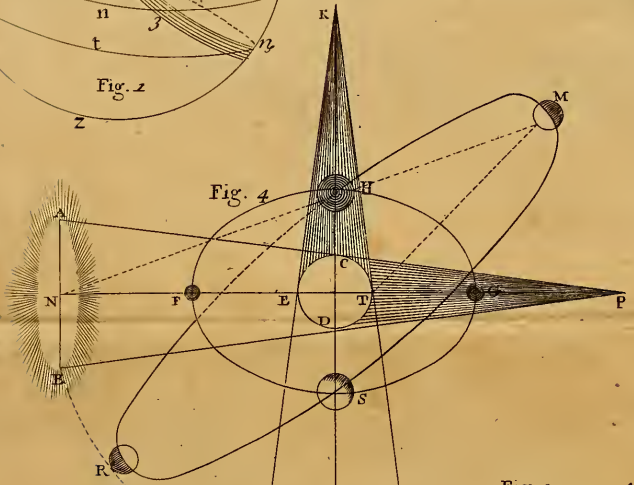


Fig. 4

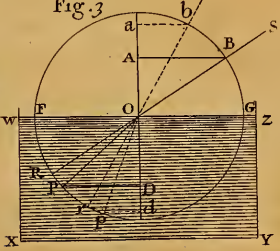


Fig. 3

facing p 842.

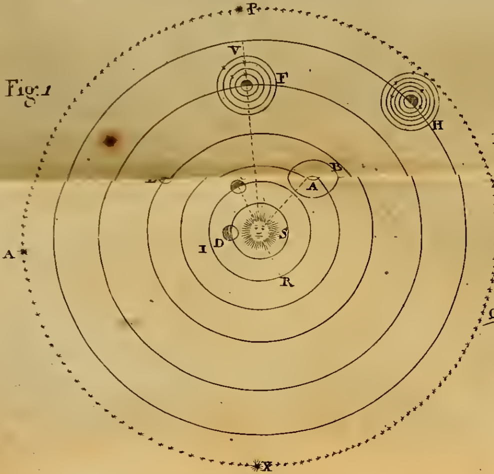


Fig. 1

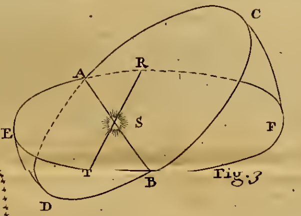


Fig. 3

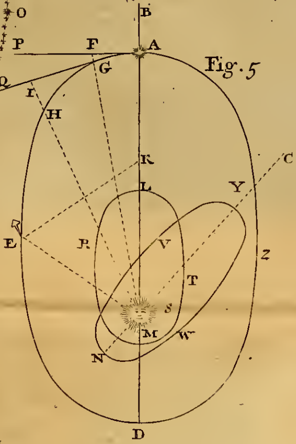


Fig. 5

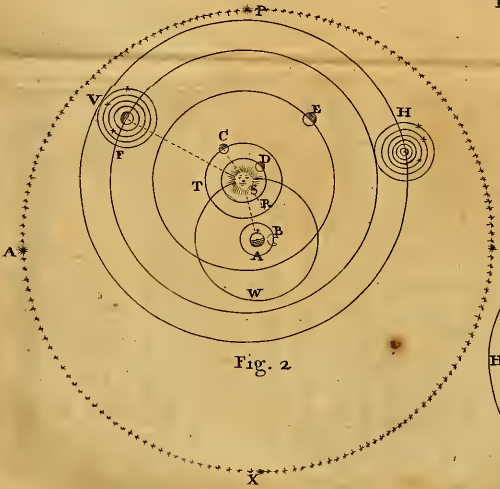


Fig. 2

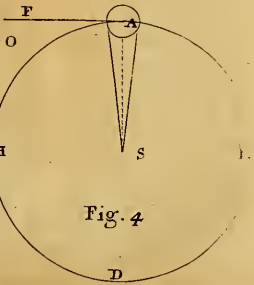


Fig. 4

CONTEMPLATION XXV.

Of the Unſpeakable Number, and Unconceivable Smallneſs of the Particles of which the UNIVERSE conſiſts.

SECT. I. *Tranſition to the Smallneſs of Parts.*

IF now, after having Contemplated the viſible World in ſome of its Parts, we turn our Thoughts farther, to thoſe ſo wonderfully ſmall and numerous Particles of which the former conſiſts; and then conſider the Laws which they continually obey, tho' ignorant of the whole, and even of themſelves too; and which Laws the Great Creator has been pleaſed to render ſubſervient to the Execution of his marvellous Purpoſes, that Man muſt be quite blind and inexcuſable, that cannot diſcover therein, the Power, Wiſdom and Goodneſs of an adorable Ruler of the Univerſe.

The Reader muſt not expect to meet here with an exact Deſcription of the Figures thereof, foraſmuch as without ever being thoroughly fathom'd or comprehended, they will always furniſh new Matter of Inquiry to learned Men, as long as this Univerſe ſhall be preſerved in its preſent State and Condition. We ſhall therefore only conſider ſome Matters and Bodies with reſpect to their Smallneſs, not perhaps ſo thoroughly as the accurate Truth of the Thing may require, but only ſo far as Experience may lead us therein.

SECT. II. *All Bodies conſiſt of ſmall Parts.*

NOW that all viſible Bodies do conſiſt of an unconceivable Number of ſuch little Parts, is already admitted by all Philoſophers, and demonſtrated too by ſo many Experiments and Proofs, that no Body who has taken the leaſt trouble of examining the Nature of Creatures, can entertain any kind of doubt thereof. Concerning which, *Rohault*'s *Phyſics*, *Boyle*'s *Subtil. Effluvia*, *Keill*'s *Introduction*, and other Books may be conſulted.

SECT. III. *Our Conceptions muſt be Rectified.*

BUT as our Imagination is uncapable to repreſent to us the amazing Magnitudes of the Heavenly Bodies, ſo likewiſe we find it as little able to give us juſt Ideas of the Smallneſs of the Parts whereof all viſible Things are compoſed; for which Reaſon as the former, ſo likewiſe the latter is by many thought Incredible, eſpecially by ſome of thoſe, who, when they conceive Things according to Truth are afraid they ſhall diſcover in them a great and terrible God.

SECT. IV. *A Cubical Inch contains a Million of viſible Particles.*

ALL kind of viſible Bodies may be divided into *Fluid* and *Solid*; we will begin with the Firſt:

And before-hand advance what Mr. *Boyle* in the beginning of the ſecond Chapter *de Subtil. Effluv.* affirms to appear by Experience; namely, that the Length of an Half-Inch, can be divided into 100 Parts, which ſhall all of 'em be big enough to diſtinguiſh themſelves for Uſe; but we, to prevent all Cavilling, will only maintain the ſame of an entire *Rynland*-Inch; from whence it follows, that a Cubical Inch, or a ſquare Stone, which is an Inch long on all Sides, contains a Million of ſuch little Cubes, each of which in all their Dimenſions, or in their Length, Breadth and Thickneſs, are no more than the $\frac{1}{100}$ of an Inch long, which is known to every one that is a little verſed in the Principles of Geometry.

So that we may ſafely lay it down for a Truth, ſince if the Length of ſuch a ſmall Cube is viſible, the whole little Cube will be much more viſible, *That a Cubical Inch contains a Million of viſible Parts.*

SECT. V. *A Cubical Inch of Water contains the like Number of Parts.*

Now if the Point of a Needle can be ground ſo ſharp, that the Breadth of it may be equal to the Breadth of ſuch a ſmall viſible Particle; and that this Point were to be juſt dipt in Water, and being drawn out again, ſhould appear wet, or that ſome Water cleave to it, all which may be allowed without any Difficulty: If then it ſhould be farther ſuppoſed, that there was but one only Particle of Water that ſtuck to it, and (for the more convenient Computation) that it was as thick as the little Superficies of the Point of the ſaid Needle; and moreover, of a Cubical Figure, it is plain from the Premiſes, that it is no bigger than $\frac{1}{1.000,000}$ Part of a Cubical Inch of Water, and conſequently that ſuch an Inch contains a Million of Water-Particles, which if they were ſeparated, would each of 'em be ſo big as to be viſible. From whence it follows, that ſuch a vaſt quantity of Cubical Inches of Water as are in the Univerſe, in Air, Earth and Water, and are moved, muſt certainly contain ſo many Millions of Parts, and be as certainly moved.

SECT. VI. *A Cubical Inch of Water Rarified in an* Eolipile, *will yield above* 13300 *Millions of Parts.*

BUT to proceed a little farther; Mr. *Boyle*, in the Third Book of the above-mentioned Treatiſe, ſays, that (See *Tab.* XXIII. *Fig.* 3.) an Ounce of Water E F G, being put into a Copper Globe A, in which there was a little Hole at B; the ſaid Globe commonly called by the Learned an *Eolipile*, was put upon the Fire; whereupon the Vapours of the Water begun to be protruded thro' the ſaid little Hole B, which produced a Pyramid of Vapours D B C, for the Space of 18 or 20 Minutes; the Length of which B R, was twenty Inches, and the greateſt Breadth at C D, was of one Inch: Yet ſo, that at the Diſtance B M, (being five or ſix Inches farther than B R) they could perceive vapoury Clouds ſtill hanging together, which extended themſelves to the Breadth of four or five Inches at K L.

If now for the more eaſy Reckoning, we conſider the long Pyramid B D C, joyned to the ſhort one D C K L, as one only Pyramid; the Length of which from B to R, is of 21 Inches, and the Diameter from C to D of $1\frac{1}{2}$ Inch, the Superfices of the Circle C N D G will be $\frac{99}{56}$ Superficial Inches, which Multiplied by 7, (being the $\frac{1}{3}$ of B R or 21) will amount to the Magnitude of $\frac{99}{8}$, or $12\frac{3}{8}$ Cubical Inches for the whole Vapour-Pyramid.

If this had been computed nicely according to Mr. *Boyle*'s Meaſure, the long Vapour-Pyramid B C D, B C D, together with the ſhort Cloud-Pyramid C D L K, would amount to above 32 Cubical Inches, tho' we ſhould reckon B R to be but 18, C D 1, R M 5, and K L 4 Inches; but for the greater Conviction, and to prevent all Cavilling, we have reckoned it all to be but 13 Inches.

Let us now ſuppoſe, that one of the Particles of the Vapours ruſhing out of the aforeſaid *Eolipile*, runs the Length from B to R in the Second of a Minute; ſo that in every Second there is a new Vapour-Pyramid formed: There would then in 18 Minutes, or in 180 Seconds, ſo many different Pyramids have come out.

Now each Vapour-Pyramid makes $12\frac{7}{8}$ Cubical Inches, and conſequently all ſuch Pyramids as are formed from one Ounce of Water, will produce $12\frac{7}{8}$ times 1080, or 13,365 of the like Inches. If now in each viſible Particle of all theſe Pyramids there is but one Particle of Water (ſince there are a Million of 'em in one Inch) there will be in the whole 13,365,000,000, and conſequently one Ounce of Water may be really divided into 13,365 Millions of Parts at leaſt.

But ſince it is deſired to know farther, into how many Parts an Inch of Water may be likewiſe divided after the ſaid manner; let us ſuppoſe, that a Cubic Foot of Water weighs 64 Pounds, and that there are 10 Inches to a Foot; accordingly a ſolid Foot will contain 1000 of ſuch Inches, and at the rate of 16 Ounces to a Pound, there will be 1024 Ounces in 64 Pounds. From whence it is eaſie to prove, that a Weight of one Ounce makes $\frac{1000}{1024}$ or $\frac{250}{256}$ of (or rather almoſt) an Inch; ſo that we may ſafely enough affirm, that a Cubical Inch of Water is according to this way diviſible into 13,000 Millions of Parts.

SECT. VII. *There may hang above* 13,000 *Particles of Water to the ſharp Point of a Needle.*

NOW it appears from *Section* the 5*th*, that the Water which may ſtick to the extream Point of a Needle, which is ſo ſharp, as to be juſt viſible, and the Breadth of which is $\frac{1}{100}$ part of an Inch, may ſafely be allowed to amount to the thouſand thouſandth part of an Inch.

Therefore it is ſufficiently certain, that this little Water that ſticks to ſuch a fine Point does conſiſt of not leſs than 13,000 Particles, if it be only a little Cube of Water that has the ſame Breadth.

SECT. VIII. *That a Drop of Water is diviſible into above* 26,000,000 *Parts.*

BUT now let us compute with Amazement, how many Parts are to be found in one Drop of Water, upon the Suppoſition which has been juſt now proved, that as oft as one dips the Point of a Needle or fine Pin, and ſomething adheres thereto, ſo often there are 13,000 Particles of Water requiſite to compoſe the ſaid Drop.

Now to form a rough Conception of this Matter from another Method; let a Drop of Water be ſuppoſed to be of the Weight of a Grain, of which 480 go to an Ounce *Troy*-Weight, and compute according to the Rule of Three, that if 480 Grains gives $\frac{250}{250}$ Parts of an Inch, what gives one Grain; and we ſhall find it to be full $\frac{1}{491}$ Part of an Inch.

Now to loſe nothing, and to allow enough, let us make the Calculation with a ſmaller part of an Inch, namely, with the $\frac{1}{500}$ thereof; and ſuppoſe that a Drop, tho' it be greater, does not contain more Water-Particles.

Now a Cubical Inch of Water contains 13,000 Millions, or a Million of times 13,000 Particles, conſequently $\frac{1}{500}$ of an Inch, or one Drop, contains 2000 times 13,000 Water-Particles, or in one Sum 26.000,000, that is, ſix and twenty Millions thereof; of which if we again caſt away ſix Millions, becauſe we don't deſire to have too much granted to us, it ſeems plain beyond Contradiction, that *in one Drop of Water* no bigger than $\frac{1}{500}$ of an Inch, there are at leaſt not fewer than *twenty Millions of Water-Particles.*

SECT. IX. *Convictions from the foregoing.*

BEFORE we proceed any farther, let an Atheiſt ſtop a little here, and conſider with us, how great and how penetrating that Providence and Direction muſt be, which before a Drop of Rain-Water of the Quantity and Weight only of one Grain ſhall fall down upon the Earth, has thought fit to compound it of ſo many Millions of Parts.

And if he ſhould refuſe, as he has hitherto done, to own a Providence herein, let him tell us, whether he can perſwade himſelf, that ſuch an innumerable Multitude of Millions of Water-Particles could by meer Chance, or without any Wiſdom and Direction for ſo many thouſands of Years continually and inceſſantly proceed from Seas, Rivers, and other moiſt Places, riſe up into the Air, divide themſelves into Clouds, as it were into ſo many Armies; where floating in that thin Matter, they are carried by the Winds towards ſo many different Parts, in order to compoſe whole Streams and Rivers; to deſcend in Rains upon the dry Ground; to cauſe the Fruits of the Earth to grow; to furniſh Drink to all kinds of Animals; in a Word, to perform all thoſe Functions and Services which we have before aſcribed to Water, and to preſerve the whole Globe of the Earth with almoſt all that is upon it, or proceeds out of it, alive and in good Condition. Certainly if this Atheiſt be any ways reaſonable, he muſt ſtand amazed: *Firſt*, At that Power which has made ſo many Thouſand Millions of Water-Particles, as are to be found in Brooks, Rivers and Seas, and preſerved them in their Motion, Figure, and Quantity. *Secondly*, He can never ſufficiently praiſe that moſt adorable Wiſdom that has ſeparated, and as we may ſay, rent all theſe Particles, and render'd each of 'em, how little ſoever they be, looſe and free from the reſt; without which Diviſion they could not have aſcended by reaſon of their Weight, nor hardly been of any Uſe. And *Laſtly*, That he is bound to return Thanks to this ſo gracious Benefactor, who has made ſuch an unſpeakable Number of Beings ſubſervient to his, and all other Mens Advantages, after ſo multifarious a manner.

SECT. X, XI, and XII. *This Hypotheſis founded upon the Obſervations of Mr.* Leuwenhoek, *namely, That a Drop of Water contains many more than one Million Millions of Parts; the ſame applicable to all kinds of Liquids.*

I HAVE been willing to prove here by degrees, that the Particles of Water are exceeding ſmall, to the end, that I might not at firſt deter our Imagination from Contemplating the ſame, by reaſon of ſuch a Smallneſs, of which it can ſcarce poſſibly frame any *Idea* to itſelf; and therefore the Reader will be pleaſed to judge from what follows, whether he muſt not agree, that altho' the now computed Smallneſs does ſeem already to eſcape our Imagination, yet that it is far different from that which we muſt neceſſarily allow to be found in the Particles of Water.

Now to ſhew this, we will lay down for a Foundation, the Experiments of Mr. *Leuwenhoek*, as they are deſcribed by him in his Letter of the *12th* of *Nov.* 1680, p. *29* ; where he relates, that he diſtinguiſhed in Pepper-Water, in the Sperm of Animals, *&c.* three ſorts of *Animalcula* of different Sizes, of which if we take the Diameter of the ſmalleſt for the Meaſure of the others, and call it an Unit, that of the Second or next biggeſt *Animalculum* or Inſect will be 10, and that of the Third or biggeſt 100 times as long as the Diameter of the Second ; ſo that the Diameter of this laſt, is 1 × 10 × 100, or 1000 times as long as that of the Firſt.

If now for the more convenient Calculation, this laſt *Animalculum* and a Grain of Sand be ſuppoſed to be of the ſame Figure, for Inſtance, that each of 'em be either Globular or Cubical, the Grain of Sand will be ſo much bigger than the Body of this *Animalculum* as the Cube 1,000.000,000, of the Diameter 1000 of the laſt is bigger than the Cube 1 of the Diameter 1 of the firſt, and conſequently we ſee that *ſuch a Grain of Sand is equal to* 1000 *Millions of theſe* Animalcula, *each of which are viſible thro' a Microſcope.*

Now Mr. *Leuwenhoek* (in his Diſcoveries the *26th* of *April* 1679, p. 14.) ſuppoſes that 100 Grains of Sand are equal to an Inch in Length ; ſo that 1.000,000 of ſuch Grains compoſe a Cubical Inch.

If then we argue after this manner :

Since 1,000.000,000 *Animalcula* go to one Grain of Sand, and 1.000,000 Grains of Sand to an Inch, which we here reckon at $\frac{1}{10}$, and not $\frac{1}{12}$ part of a Foot) there will be contained in ſuch a

Cubical Inch, 1.000.000,000.000,000 of thoſe *Animalcula.*

But according to *Sect.* VIII. it appears, that one Drop of Water is $\frac{1}{500}$ of an Inch ; ſo then according to that Calculation, 2.000,000.000,000 *Animalcula* are but equal to ſuch a Drop of Water.

But to prevent any Objections againſt the ſaid Calculation, we will abate the half of it, according to which there will be then a *thouſand times a thouſand Millions of theſe* Animalcula *capable of being contained in one Drop of Water.*

This laſt being now proved about Water, we may eaſily ſee that it is applicable to many other fluid Matters, eſpecially to ſuch as are wet, and which by ſticking to ſolid Bodies do moiſten the ſame; for which reaſon we need not ſay any thing of Oil, Spirits and the like ; but we will add a few words about other Fluids that are not moiſt.

SECT. XIII, XIV, and XV. *The Smallneſs of the Particles of Air, Fire and Light.*

THE abovemention'd Mr. *Leuwenhoek* in his *7th Continuation*, p. 424, ſays, that having preſſed the Air and Blood out of the little piece of the Lungs of a Sheep, he found that many of the Air-bubbles were ſo ſmall, that they were hardly viſible even with a Microſcope, inſomuch that they muſt be ſmaller therefore than thoſe *Animalcula* which we have lately ſpoken of from him, and which could be ſeen : And conſequently a Grain of Sand is more than equal to 1,000 Millions of the ſame, or a Cubical Inch will contain above 1,000.000,000.000,000 Particles of Air.

Now tho' ſome think they have reaſon to believe, that the Particles of Air are bigger than

thoſe

fronting p. 852.

TAB. XXIII.

Fig. 2

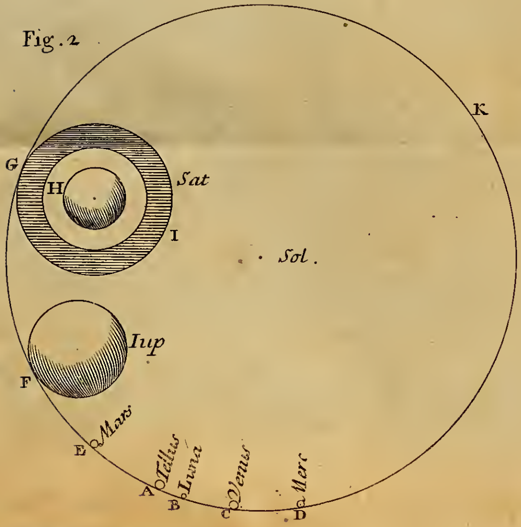
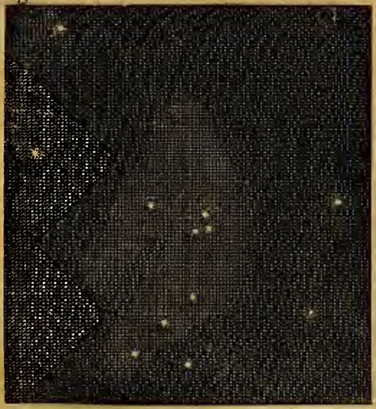
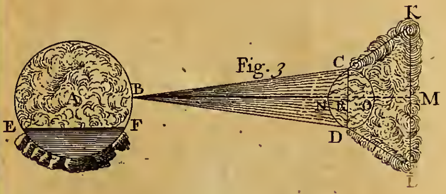


Fig. 1





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thoſe of Water, becauſe the latter can paſs thro' Orifices or Holes, which ſeem impervious to Air; yet we ſee that the Particles of this latter are exceeding ſmall, ſince it might be demonſtrated here, That by reaſon of their Inviſibility they far ſurpaſs in Smallneſs the aforemention'd *Animalcula.*

Certainly that they do likewiſe penetrate thro' very narrow Paſſages, is not only plain from Plants, into all which they inſinuate themſelves, tho' we cannot diſcover any Pores or Cavities in ſome of 'em; but it is likewiſe well known to thoſe that handle Air-Pumps, who find how much Pains it coſts them before they can exhauſt the Air; at leaſt if it may be proved, as perhaps it can, that the Particles of Water are ſmaller than thoſe of Air; this is ſtill ſufficient to convince us particularly, that we are far from having as yet inveſtigated the real Smallneſs of the Particles of Water.

Now how much more minute Parts, Fire conſiſts of, than all theſe above-mention'd Fluids, may appear from hence, that Air, Water, Oyl, and the like, are found to conſiſt of ſuch groſs Parts, that they cannot paſs thro' the Pores of Glaſs and other hard Bodies as Iron, Steel, *&c.* and can therefore be excluded or kept out from Veſſels made of thoſe Materials; whereas there are no Paſſages, tho' ever ſo ſmall, in any Bodies thro' which the Particles of Fire cannot penetrate; which appears by their rendring all Bodies either glowing, that is to ſay, full of Fire-Particles, or putting them into Fuſion, or cauſing them to evaporate; of all which nothing could come to paſs, if the Fire were not able to inſinuate itſelf into the innermoſt Parts of thoſe Bodies.

We ſhould now paſs on from the Fire in the laſt Place, to its Effluvia or Matter of Light, and give the Reader here a rough Sketch of the Fineneſs of the Parts thereof, ſince we are far from being able to trace the Multitude and Smallneſs of them, and particularly have given a certain Demonſtration how many Particles of Light may be ſafely affirmed to fly out of a burning Candle in the Second of a Minute.

They that have not a mind to read the following Demonſtration, may paſs on to *Sect.* XVI, and XVII.

A Calculation of the Number and Smallneſs of the Particles of LIGHT.

I. IT is ſuppoſed, That the Flame of a Candle of Six to the Pound, may be ſeen at the Diſtance of 2000 Paces, or 10,000 Foot, each Pace being computed at 5 Foot; that is, from O to E. *Tab.* XXIV. *Fig.* 1.

II. It is plain then, Since the ſaid Flame may be ſeen at the ſame Diſtance all round, that it fills the whole Globe or Circle R Q E S.

III. Now to find the Bigneſs of this Globe R E, we muſt firſt obſerve, that the whole Diameter is equal to twice O E, that is, 20,000 Foot.

And foraſmuch as 100 Is to 314 As the Diameter R E To the Circumference R Q E S, we ſhall find, by the *Rule of Three*, that this Circumference includes 62,800 Feet.

IV. Now if we multiply the whole Diameter by the Circumference, and that Product by the ſixth Part of the Diameter, it will produce the ſolid Contents of the Globe R Q E S, being 41.866,000.000,000 Cubical Feet, as is known to all Geometricians.

V. If now we divide a Foot into ten Parts, and call each of 'em an Inch, 1 Cubical Foot will contain 1000 Cubical Inches; as the aforemention'd Globe will contain 41,866.000,000.000,000 Cubical Inches, which for Shortneſs, and that we be not every time obliged to write the ſaid Sum at length, we will expreſs by placing the Number of the Cyphers omitted over the firſt Cypher: So that according thereto, ſuch a Globe contains $41,8660^{11}$ of ſuch Inches.

VI. Again, Since a Candle of 6 to the Pound, will burn Five Hours, it may be eaſily computed, how much thereof will be ſpent in a Second; for allowing 3600 Seconds to one Hour, and to every Ounce (16 of which make a Pound) 480 Grains, Apothecaries Weight, we ſhall find by the ſaid *Rule of Three*, there is burnt in one Second $\frac{16}{225}$, that is, full $\frac{1}{14}$ Part of a Grain of Tallow.

VII. Now to know how many of theſe Grains of Tallow, or Wax, go to one Foot:

Let us ſuppoſe, *Firſt*, That a Cubical Foot of Water weighs 64 Pounds, to which the Weight of moſt Waters will amount.

And, *Secondly*, That 5 Feet of Water are as heavy as $5\frac{1}{3}$ Cubical Feet of Wax. Vid. *De Stair*, *Senguerdius*, &c.

Suppoſing then Wax and Tallow to be of equal Weight, ſince the Experiment of burning 5 Hours has been made with a Tallow-Candle, 5 Feet of Water will amount to 320 Pounds Weight, and ſo will $5\frac{1}{3}$ or $\frac{16}{3}$ Feet of Wax or Tallow.

So then a Cubical Foot of Wax weighs 60 Pounds, that is, 460,800 Grains, and conſequently 1 Grain the $\frac{1}{460800}$ Part of a Cubical Foot of 1000 Inches, which being reduced to ſingle Inches, amounts to $\frac{10}{4608}$ or $\frac{1}{460}$ of a Cubical Inch.

VIII. Now if we conſider here likewiſe the aforemention'd Velocity of Light, and ſuppoſe O E the Diſtance of the Candle O to the End of the enlighten'd Globe Q E R S, to be 10,000 Feet; and whereas it has been already proved, that the Light of *Jupiter's* Moons paſſes thro' the whole Space which is between the Sun and Earth, or 12,000 Diameters of the Earth, in the $\frac{1}{8}$ Part of an Hour, or 450 Seconds, that is, in one Second $26\frac{2}{3}$ of the ſaid Diameters; it will follow then, that every one of theſe Diameters being computed at 39.231,564 *Paris* Feet (See *Whiſton. Prælect. Aſtron.* p. 13.) according to the moſt accurate Admeaſurement of the *French*, the ſaid Light will run 1,046.175,040 of the ſaid Feet; ſince ſo many of 'em go to the ſaid $26\frac{2}{3}$ Diameters of the Earth.

But in caſe any one ſhould affirm, that this Calculation is too large, foraſmuch as it ſuppoſes that the Light of a Candle runs as ſwift as that of the Sun, he muſt be pleaſed to obſerve, *Firſt*, That it has not been yet demonſtrated, that one kind of Light moves faſter than another. For if a Man were placed in a great Dark Room, and a Hole were made in the ſame, for the Day-Light to paſs thro', or before which Hole a Candle were held, I don't think that the Light of the Sun would reach him ſooner than that of a Candle, at the ſame Diſtance. But it is hardly poſſible to make ſuch an Experiment, becauſe the Difference between ſuch great Velocities of both theſe Lights is not to be obſerved. *Secondly*, Becauſe Light does probably not vary its Swiftneſs at all; ſince the ſurprizing Emanation of Light, of which mention has been made before, and is now here repeated, is not obſerv'd with reſpect to thoſe Rays that proceed immediately from the Sun, but only as they be reflected from *Jupiter's*

Moons. So that it retains ſtill this Velocity after having run above five times the Length of that Space between the Sun and Earth ; for ſo have we ſhewn above, in *Contemplation* XXIV. that *Jupiter* is at ſuch a Diſtance from the Sun. *Thirdly*, Beſides, ſeveral other ways by which we might prove the unconceivable Velocity of the Particles that proceed from a burning Candle, the ſame does appear by the Effects it has in melting Glaſs, Enamels, Metals, and other very hard Bodies ; which Force, ſince it can't be aſcribed to the Magnitude of the Particles, they being exceeding ſmall, muſt needs reſult from their Velocity ; it being a known Rule in Mechanicks, that all the Force of Bodies is in Proportion to their Maſs multiply'd by their Velocity.

But that we may here likewiſe concede enough, let us ſuppoſe, That inſtead of ſo many more than 100,000 times, in which the Light would fill this Globe in one Second, it be only 1000 times, whereby the Motion of the ſaid Light is granted to be above 100 times ſlower, as it muſt be, if we compare its Velocity with that of the Light which comes down to us from *Jupiter's* Moons.

IX. We ſuppoſe farther, that the ſmalleſt *Animalcula* that can be render'd viſible by the beſt Microſcope, is much bigger than any Particle of Light. *Firſt*, Becauſe many more Particles of Light than one are requiſite to render it viſible. *Secondly*, Becauſe theſe *Animalcula* are viſible, whereas the Particles of Light are inviſible. *Thirdly*, Becauſe Light can paſs thro' the imperceptible Pores of Glaſs, which the ſmalleſt Inſect in the World can't do. And, *Fourthly*, This appears very plainly to ſuch as know that theſe *Animalcula* being view'd againſt the Sun with a good Microſcope, it is obſerv'd not only that they are tranſparent, but alſo that the Rays which paſs thro' them, repreſent all the Colours of the Rainbow; to produce which, many and different Rays are neceſſary. The *Phænomenon* is familiar to thoſe that deal in Microſcopes, and we find it confirm'd in the ſeventh *Continuation of Leuwenhoek*, p. 100. We premiſe this, for the ſake of what follows, namely, That an inexpreſſible Number, or 10^{20} (a Unit with 20 Cyphers) of Light-Particles is really contain'd within the Space of one of theſe ſo ſmall Inſects; as alſo to aſſiſt the Weakneſs of our Imagination.

X. It is likewiſe known, That when a burning Candle placed at O, (*Tab.* XXIV. *Fig.* 1.) and diffuſing its Light as far as E, and filling the whole Globe E Q R S, communicates the ſame to the Point A, which is near the Candle, the ſaid Point A, will be as much more enlighten'd than another Point E, which is at an equal, or greater Diſtance from thence, as the Square of the greateſt Diſtance (for inſtance, of O E) is greater than the Square of the Small one O A.

In the Language of the Mathematicians, what we have laid down above, is expreſs'd in the following Manner:

The Number of the Particles of Light in two equally great, but unequally diſtant, Places from the Flame, are to each other in an inverted Ratio of the Squares of their Diſtances. This has been ſhown more circumſtantially above in *Contemplation* XXIV. and is well known to all Mathematicians.

XI. To proceed a little farther:

Suppoſe then that O E, or the utmoſt Extent of the Light in the illuminated Circle Q R S E, be of the Length of 10,000.000,000 or 10^{10} of ſuch *Animalcula* as Mr. *Leuwenhoek* view'd with his Microſcope (why we reſtrain it to juſt this Number, ſhall be ſhown hereafter in *Num.* XXIII.) and let the Length of the Ray O E be divided into the ſmalleſt Parts O A, A B, B C, C D; allowing to each of them the Length of one of the ſaid *Animalcula.*

If now it be farther ſuppoſed, That in the Space of that *Animalculum,* which is the laſt and moſt remote from the Candle O, as here at V E, there be but one ſingle Particle of Light; and that the nearer theſe Points come to the Candle in every following Space, as D O, C B, B A and A O, the Light-Particles always and continually increaſe in the *Animalcula,* according to the aforeſaid Rule *Num.* X. It may be accordingly known, how many Particles of Light are contain'd in the Space of an *Animalculum,* the Diſtance of which from the Candle O, is likewiſe known, as here at O A, A B, B C, *&c.*

XII. For this Purpoſe, and for the ſake of Order and Conveniency, Let there be perpendicular Lines of an indefinite Length drawn upon the Points A, B, C, D, and all the Partitions of theſe Lengths of the *Animalcula,* ſuch as A *g*, B *h*, C *i*, D *k*, E *q*, *&c.* in order to deſcribe thereby the Number of Light-Particles which are to be found in the Space of each particular *Animalculum.*

And having taken at E *q* the Length E F, equal to an Unit, foraſmuch as in the laſt Space V E, there is ſuppos'd to be contain'd but one ſingle Particle of Light; and O E being found as above, to be equal to $10^{\underline{10}}$, ſay, according to the foregoing Rule:

1. As the Square of O A, or 1, Is to the Square O E, or $10^{\underline{20}}$: So is F E (a Light-Particle in V E) To *A a*, $10^{\underline{20}}$; or the Number of Light-Particles in O A.

Take then in the indefinite Line A *g*, the Length A *a* equal to $10^{\underline{20}}$, ſo will this Line A *a* repreſent the Number of the Particles of Light at A, or in the *Animalculum's* Space O A.

2. As 4, or the Square of O B, which contains two *Animacula*, Is to the Square of O E, or $10^{\underline{20}}$, which contains the Length of $10^{\underline{10}}$ *Animalcula* : So is 1 or F E To $10^{\frac{20}{4}}$ or $250^{\underline{18}}$ B *b*.

3. So likewiſe when O D contains 10 *Animalcula* in Length, to find D *d*, or the Light-Particles that are in D.

As 100, the Square of O D, 10 = To $10^{\underline{20}}$, the Square of O E : So is 1, or F E, To $10^{\frac{20}{100}}$ or 10^{2}, or D *d*, and ſo of all the reſt.

XIII. From hence then it appears, that if Perpendicular Lines, ſuch as A *a*, B *b*, C *c*, D *d*, *&c.* be let fall upon all the Partitions A, B, C, D, *&c.* as the Line O E is divided into $10^{\underline{10}}$ Parts, and each of them amount to the Number of the Light-Particles contain'd in the Spaces of the *Animalcula* O A, B C, A B, D D, *&c.* there would be nothing requiſite more than to add up the Numbers of all the ſaid Perpendicular Lines together, in order to know how many Particles of Light are contain'd in all the *Animalcula* Spaces of O E, as they increaſe after the ſaid manner from E to A, in which there is no Difficulty,

XIV. As likewiſe by drawing G F parallel to O E, ſo that A G, B *r*, C *s*, D *t*, *&c.* be each of 'em equal to F E, or an Unit; that the Sum of all thoſe Units will produce the Number of all the Light-Particles that are contain'd in O E; if in each *Animalcula*'s Space, O A, A B, B C, C D, *&c.* there be found but one Light-Particle.

Now ſince O E is ſuppos'd to conſiſt of $10^{\underline{10}}$ *Animalcula* Spaces, the Number of Light-Particles in the ſame will likewiſe be $10^{\underline{10}}$.

XV. From whence it therefore follows, that the Number of Light-Particles in the Length O E, ſuppoſing there be one in each *Animalcula*-Space, Is to the Number of the ſame, ſuppoſing likewiſe, that they increaſe according to the Rule *Num.* X. As 10^{10}, or ſo many Units as are contain'd in the Lines A G, B *r*, C *s*, D *t*, *&c.* Are to the Produce of all the Numbers that compoſe the Perpendicular Lines A *a*, B *b*, C *c*, D *d*, *&c.*

XVI. It is not neceſſary to prove that the Numbers of all theſe Perpendiculars A *a*, B *b*, C *c*, D *d*, *&c.* do contain ſo great a quantity.

Since the Firſt and greateſt A *a* being 10^{20}.

The Second B *b* will amount to $10^{\frac{20}{4}}$, or 250.

The Third C *c* $10^{\frac{20}{9}}$.

The Fourth D *d* $10^{\frac{20}{16}}$.

And ſo forth; each of theſe Lines equal to the Line A *a* or 10^{20} divided by the Squares of their Diſtances from O; all which amounting to the Number of 10^{10}; ſo as the laſt F E, by the Unit, will produce a great Sum, which to compute here would be a very great Trouble, and require too much Time and Room.

XVII. That we may not therefore be deceiv'd in our Calculation, we ſhall make choice of a much ſmaller Sum than we need do, and therefore only retain the Number 10^{20}, that alone being the greateſt quantity of Light-Particles in the Space of one of the *Animalcula*, or the Line A *a*; and we will throw away the reſt B *c*, C *c*, D *d*, *&c.* which would likewiſe amount to a vaſt Sum.

And having done ſo, it will eaſily follow; that the increaſed Light-Particles 10^{20}, or A *a* (*Num.* XVI.) Are to the Number of Light-Particles in O E, As one in the Space of each *Animalculum*, or to 10^{10} (*Num.* XIV.) As 10^{10} to 1. Or that (if we admit the Increaſe *Num.* X.) the *Animalcula* in O E are 10^{10} times more, than if we were to ſuppoſe but one in each of the Spaces between O and E, Q R S E. This is applicable to all the Rays like O E thro' the enlighten'd Globe, and conſequently to the ſaid whole Globe.

XVIII. Before I proceed, I beg leave to obviate the Opinions that ſome People may entertain of theſe Matters:

Namely, That ſince the Curve-Line *a, b, c, &c.* F which connects all the Tops *a, b, c, &c.* of the Perpendicular Lines A *a*, B *b*, C *c*, *&c.* which are here drawn ſo cloſe to each other, is of a known Property; which, if we call each of the Lines or Diſtances O A, O B, O C, *&c.* x, and the reſpective Perpendiculars A *a*, B *b*, C *c*, *&c.* each y, and the Line O E, a, and E F, b, and expreſs the ſame by the following Algebraic Equation, $x x y = a b$. A Mathematician will wonder, perhaps, why I did not find the *Area* of the Magnitude of the *Mixtilineum* A *a* F E by Approximation, or even after the Method of *Mercator*, *Wallis*, and other great Mathematicians; to the end, that after having compared the ſame with the Greatneſs of the Rect-Angle A G F E, to find the Proportion from thence of the increas'd Number of Particles of Light in O E to the Number of the ſame O E, if there were but one Particle in the Space of each *Animalculum*; which has been done, it may be, by others on the like Occaſion.

But they muſt be pleas'd to obſerve; *Firſt*, That I have omitted theſe Methods, becauſe all of 'em ſuppoſe, that the Line O E is to be divided into infinite ſmall Parts, as O A, A B, B C, *&c.* whereas we have only adapted our Diviſions to ſuch Parts as are equal to the Space fill'd by each of thoſe *Animalcula* that are viſible thro' a Microſcope, which is yet bigger an infinite Number of times than one of the infinite Parts.

Secondly, We have given one Reaſon in *Num.* XVII. which will make our Concluſions much more acceptable, becauſe we chooſe ſo much ſmaller a Number.

Thirdly, What we here write is not ſo much for great Mathematicians, as for others that are of a good natural Underſtanding, tho' not thoroughly vers'd in Lines and Figures; wherefore, when we can uſe other Methods of Proving, we avoid as much as poſſible thoſe of the Mathematicians; my chief End being to render my ſelf intelligible even to the meaneſt Capacity, rather than to pleaſe the Learned, provided I can make the Truth appear in ſuch a manner.

XIX. To draw therefore thoſe Concluſions which we have in View from theſe and the foregoing Principles; let us ſuppoſe, (1.) with *Leuwenhoek*, that 1000.000,000 of thoſe *Animalcula* which are viſible thro' a Microſcope, do make up one Grain of Sand, *Sect.* X. (2.) That 1.000,000 of Sands are equal to a Cubical Inch, *Sect.* X. according to which $10^{\underline{12}}$ of theſe *Animalcula* are equal to a Cubical Inch, allowing but 10 Inches to a Foot in length.

Now according to *Num.* V. the Globe Q R S E contains $418660^{\underline{11}}$ of ſuch Inches, and conſequently $418660^{\underline{26}}$ of the ſaid *Animalcula*.

XX. Let us ſuppoſe further, that in every one of the Spaces fill'd by each *Animalculum*, there is but one Light-Particle thro' the whole Globe.

XXI. If now the Velocity of Light be ſo great as to enlighten this Globe in one Second, (See *Num.* VI and VIII.) and a Candle of Six to the Pound will burn 5 Hours, there will be $\frac{1}{14}$ part of a Grain of Tallow ſpent in each Second. Conſequently there will proceed from $\frac{1}{14}$ of a Grain of Tallow $418660^{\underline{26}}$ Particles of Light, and 14 times ſo many, or $5161240^{\underline{26}}$ from a whole Grain.

XXII. But one Grain is   Part of an Inch of 10 to the Foot, *Num.* VII there proceeds therefore from one Inch of Candle-Tallow 460 times $5361240^{\underline{26}}$; or in one Number $269617040^{\underline{27}}$ Particles of Light.

XXIII. But ſuppoſing with Mr. *Leuwenhoek*, 1000 Diameters or Lengths of one of theſe *Animalcula* equal to one Grain of Sand; and 100 Diameters of one Sand, to be the Length of an Inch, and 10 Inches the Length of one Foot.

Then $10^{\underline{6}}$ Diameters of the *Animalcula* make the Length of one Foot, and $10^{\underline{10}}$ of the ſame the Length of O E, or 10,000 Feet.

XXIV. Now we have ſhown, *Num.* XVII, that altho' we throw away many Thouſands of Millions of Light-Particles in the Globe Q R S E, there be really $10^{\underline{10}}$ more Light-Particles, than when as above in *Num.* XX, we ſuppoſe but one ſingle Particle in the ſpace of each *Animalculum.* So that there proceeds from $\frac{1}{14}$ of a Grain of Tallow, $10^{\underline{10}}$ times more Particles than are ſuppoſed *Num.* XXI; and conſequently from one Inch of Tallow, $10^{\underline{1}}$ more than in *Num.* XXII; that is, from one Inch of Tallow there will proceed $269617040^{\underline{27}}$ ſuch Particles.

XXV. And all this is true: *Firſt*, Altho' we ſhould ſuppoſe that there is but one Light-Particle in the Space of one *Animalculum*, at the extreme Part of the illuminated Globe, or at V E, which every Body ſees is too little, conſidering the gradual Increaſe of Light, as we come nearer to the Candle O. And *Secondly*, although the ſaid Globe ſhould be enlighten'd but once in one Second, or that the Light paſſes from O to E in that time.

But foraſmuch as according to *Num.* VIII, the Light runs 1000 times ſwifter, and does not only run once, but 1000 times the Length of O E on all Sides, there being 1000 of ſuch Globes fill'd with Light by $\frac{1}{14}$ Part of a Grain of Tallow in one Second.

It plainly follows, that the Number found by *Num.* XXIV, muſt be multiply'd by 1000; and that one Inch of the Tallow burning in ſuch a Candle does emit $269617040^{\underline{40}}$ Particles of Light, whereby the moſt aſtoniſhing Smallneſs and Number thereof is plainly *Demonſtrated.*

SECT. XVI. *How many Particles of Light fly out of a burning Candle in a Second.*

TO know then how many Particles of Light fly from a burning-Candle in the Second of a Minute; it has been Demonſtrated from the foregoing Conſiderations, that $\frac{1}{14}$ of a Grain of Tallow is conſumed in the Second of a Minute, or, which is the ſame thing, one whole Grain in 14 Seconds. Now an Inch of Tallow contains 460 Grains, ſo that an Inch of Wax or Candle-Tallow is burnt in 460 times 14, that is, in 6440 Seconds; in which time if there proceeds $269617040^{\underline{40}}$ Particles of Light from an Inch of Tallow, there will fly out of a burning Candle in the Second of a Minute, the Number of $418660^{\underline{39}}$ Particles.

SECT. XVII. *The Particles of Light compared with the Sand of the whole Earth.*

AND ſince according to the moſt exact Admeaſurement of the *French* Aſtronomers, the Diameter of the Earth amounts to 39.231,564 *Paris* Feet, reckoning 10 Inches to one Foot, and that 100 Sands are equal to one Inch; the Number to be taken for all the Sands that could be contained in the Earth, will require a Sum of not leſs than 32 Figures, the firſt of which is a 3, and the whole too long to be expreſſed here.

Now in *Sect.* XVI, the Number there found was 44 Figures, of which the firſt was a 4.

Now let us for Conveniency, and to prevent any Diſputes, ſuppoſe that both the firſt Figures were a 1, and the reſt Cyphers or Noughts, by which we loſe an unconceivable Number of Parts:

Accordingly the Sands of the whole Earth will be $10^{\underline{31}}$.

And the Particles of Light flying out of a Candle in a Second $10^{\underline{43}}$.

The Proportion of the one to the other, will be As 1 To $10^{\underline{12}}$, or As one To a thouſand times a thouſand Millions.

From whence it may be concluded, that *in one Second* (which is commonly equal to one Pulſe of a healthy Man) *there fly out of a burning Candle of Six to the Pound, many more Particles of Light than a thouſand times a thouſand Millions of that Sand the Number the Earth can contain, or be equal to.*

I leave every one to conſider, whether this does not appear moſt amazing to him, and whether he is not bewilder'd, and loſes himſelf in the Number and Smallneſs of theſe Particles of Light, tho' there were no more of 'em; whereas every one may perceive from what has been ſaid, that if we had kept to a ſtrict Calculation, the Number thereof would very far, yea unconceivably, ſurpaſs what we have here ſet down.

SECT. XVIII. *The Smallneſs of Parts in ſolid Bodies, ſuch as Copper or Braſs,* &c.

LET us now paſs on to ſolid Bodies (tho' the Diviſion of this Tallow may likewiſe be ſerviceable to our Purpoſe) and endeavour to ſhew, *Firſt*, That they conſiſt of a vaſt Number of different Particles. Some of the moſt intelligible Methods ſeem among others to be the following.

1. Mr. *Boyle* (*de Subtil. Effluv.*) ſays, that a Grain of Copper having been diſſolved by him

in Spirit of *Sal Armoniac*, did thereby communicate a viſible blew Colour to 28,434 Grains of Water.

Now if we ſuppoſe that each Grain of Water was impregnated with one Particle of Copper, it will follow from thence, that one Grain of Copper was divided at leaſt into ſo many Parts as there were Grains of Water.

But ſuppoſing with Mr. *Boyle*, that $\frac{1}{100}$ of an Inch in Length is viſible, $\frac{1}{100,000}$ of a Cubical Inch will be likewiſe viſible.

And ſince one Foot of Water of 64 Pounds (allowing 12 Inches to the Length of one Foot) contains 1728 Cubical Inches; the aforeſaid 28,534 Grains will amount to above 100 of the ſaid Inches; and conſequently in all thoſe Inches there will be more than 100,000,000, or one hundred Millions of viſible Parts; wherefore if there be but one Particle of Copper in every viſible Particle of Water, a Grain of Copper will be thereby really divided into ſo many Parts.

SECT. XIX. *The Smallneſs of Parts in ſolid and fluid Matters in General.*

NOW how far the Parts of Gold may be really extended by human Inſtruments, has been ſhewn by *Rohault*, *Boyle* and others.

One Proof which is as applicable to all ſolid Bodies as well as fluid, may be briefly ſhewn in the already-mention'd Experiments of the Microſcopes of Mr. *Leuwenhoek*; by which it appears, that of thoſe ſmalleſt *Animalcula* which he could ſee thro' them $10^{\underline{15}}$, or 1,000.000,000.000,000 go to the making up of one Cubical Inch. Now it is certain, that if the Particles of which a Body is compoſed are ſo ſmall, that each of 'em are inviſible to the Microſcope, that at leaſt every Inch of the ſaid Body muſt conſiſt of more than $10^{\underline{15}}$ of ſuch Particles.

From whence then the ſame may be truly affirmed of all Metals, Minerals, Animals and Plants, in a word, of every thing that is viſible.

And no Body ought to be ſurpriz'd, if we ſhould add, that this Number of Parts is much too ſmall to expreſs properly the Multitude thereof; and that this may certainly be proved in many Caſes if it be conſider'd;

Firſt, That theſe ſmall *Animalcula* which are only viſible thro' the Microſcope, muſt be furniſhed likewiſe with the proper Inſtruments for Life, Motion and Procreation, as alſo with their Juices by which they are nouriſhed; to the ſmallneſs of which, no Power of human Imagination ſeems capable of being extended.

Secondly, That almoſt all Animals and Plants are Combuſtible, and may be put into a perfect Flame; for which Reaſon, if we only make a rough Eſtimate (according to what has been ſaid above, *Sect.* XVI and XVII, of the ſmallneſs of the Particles of Light) how much greater the Flame proceeding from them is, than that of a Candle; and conſequently, how many more Parts do every Moment fly out of them under the Figure of Light, all which did contribute before to the Structure of ſuch a Plant or Animal, ſuch a Multitude, and ſuch a ſmallneſs of Parts, will reſult from thence, as (to thoſe who do not ſee the force of theſe Conſequences) muſt ſeem incredible, and unconceivable even to thoſe that can ſee them.

SECT. XX. *Experiments ſhewing the determinate Properties of theſe ſmall Parts.*

NOW that theſe numerous Particles which flow from Bodies, are not only very ſmall, but have likewiſe a determinate Nature and Eſſence, has been ſhewn by the Learned Mr. *Boyle* in a particular Treatiſe, to which we refer the Reader.

But to ſay ſomething of the Matter; *Glaſs of Antimony*, as is well known to thoſe that underſtand the Virtue of it, being infuſed in Wine, will make a Vomit, tho' the *Antimony* loſes nothing ſenſibly of its Weight; and the Parts of it are ſo exceeding ſmall and fine, that an Ounce or leſs would furniſh Vomits for more People than are in the whole City of *Amſterdam*.

From whence appears, not only the ſmallneſs of thoſe Parts which it communicates to the Wine, but alſo that the Nature thereof is Determinate.

Gold, *Silver*, *Mercury*, it may be other Metals too, being diſſolved in their reſpective Menſtrums, are divided into an infinite Number of inviſible Particles; and they may be all precipitated, as the Chymiſts phraſe it, or cauſed to ſubſide in thoſe Liquors, and be returned again into their ſeveral Metals.

How ſmall the Effluvia are that come out of a *Loadſtone*, and which will even paſs thro' Glaſs to move Iron, is plain enough from ſuch an Effect; and withal, that they have their determinate Properties.

SECT. XXI. *Of the Smoak of* Benjoin.

THEY who deſire to ſee a Calculation of the ſmallneſs of the Particles that exhale from ſweet or ſtinking Matters, ſuch as Musk, Civet, Ambergreaſe, *Aſſa Fœtida*, and the like, may meet 'em in Dr. *Keil's* *Introduction*, and yet they all retain their particular and determinate Scent: To ſay nothing of the Particles which a Hare or other hunted Beaſts leave upon their Foot-ſteps, ſince Mr. *Boyle* has expreſly treated of the ſame: It may be proved from the following Experiment, without any Trouble or Charge, of how many Particles a ſolid Body conſiſts.

In a Chamber that was 24 Foot long and broad, and about 16 Foot high, I placed little Pans of Fire in 4 ſeveral Places, and ſtrewed upon each of 'em about $\frac{1}{4}$ of a Drachm of *Benjoin*; whereupon the Chamber, after ſome time, was full from one end to the other of a thin viſible Smoak.

Now the Contents of this Chamber were 9216 Cubical Feet, which being multiply'd by 1000, or the Number of Inches in a Foot (ſuppoſing it to be divided into 10 parts in Length) amounted to 9.216,000 Inches.

Now $\frac{1}{1000}$ of an Inch in Length is viſible to the naked Eye, (*Sect.* IV.) conſequently then $\frac{1}{1,000,000}$ of a Cubical Inch; ſo that there being 1.000,000 viſible Particles in an Inch, there were 9.216,000.000,000 of the ſame in this Chamber; and in caſe there were but one Particle of *Benjoin* in each, the 8*th* part of an Ounce of the ſaid Perfume would be thereby divided into more than nine thouſand, thouſand Millions of Particles, tho' the ſame be much ſmaller in quantity than an Inch.

If now we add here, not only that this Smoak diffuſed the Scent of the *Benjoin* in all parts of the Room, but likewiſe, as the Chymiſts know, that the ſaid Smoak being collected, does yield a purified *Benjoin*, called the *Flower of Benjoin*; beſides

ſides the ſmallneſs of its Parts, the ſettled and determinate Property thereof may be proved from thence; and that as well theſe ſmall exhaled Particles do retain the Nature of the *Benjoin* itſelf, as the Vapours do of the Water out of which they proceed, and into which, being collected, they are turned again.

SECT. XXII and XXIII. *Convictions from the Smallneſs of Parts in General, and in Particular.*

NOW let an unhappy Atheiſt, who has not underſtood all that has been here ſaid of the Smallneſs and Multitude of theſe Particles, but who by Reading and Reflecting has made the Contemplation thereof habitual to him; let ſuch a one I ſay, ſet before his Eyes the great Structure of the viſible World, and all its Parts; and let him conſider not only of what an innumerable, unexpreſſible, yea, and unconceivable multitude of Atoms the ſame conſiſts, but particularly, that none of 'em all have the leaſt Knowledge or Skill to create or move themſelves; and let him judge farther, that if no Wiſdom had intervened in this Matter, and that all their Motions had been produced without any Order, and by meer Chance; whether it would not be certain, that this noble Frame of Heaven and Earth would have been quickly turned into a Chaos, in which Fire, Water, Air, and all things beſides, would have been confuſedly jumbled among each other; and ſo much the more, if there had not been a Power ſo unconceivably Great, as to extend itſelf to every Individual of all thoſe thouſand thouſands of unexpreſſibly many Millions of Millions, and which could have directed and governed each of 'em in Particular; which Direction is therefore neceſſary, becauſe each of 'em have their determinate

Properties; and therefore one kind of 'em is not adapted for executing ſuch a Purpoſe as may be performed by the other.

Or if this Proof be too General for theſe miſerable Philoſophers, ſo that they will fancy to themſelves, that perhaps they may find out here or there ſome Subterfuge among this great Number of Objects, let them caſt their Eyes upon Particulars: Let them read all the modern Diſcoveries by the help of Microſcopes; let them apply themſelves to ſee with their own Eyes what they had heard before thereof; and that travelling thro' this new World, which for ſo many Ages has been Inviſible, they may Contemplate thoſe numberleſs ſtrange Things, which would have been incredible, if Experience had not render'd them certain: And when they have been aſſured by their own Sight, that for Inſtance, ſuch a little contemptible Creature as a Mite in Cheeſe appears to the naked Eye, is a a compleat Animal, having all thoſe Limbs and Joints that are proper for its Motion, and it's Body cover'd with Hair; that ſuch Inſects couple with each other, lay Eggs, from which their young ones are hatch'd; that farther on the contrary, the little Eels that may be diſcover'd in Vinegar, lay no Eggs, but bring forth their young ones alive. This laſt we are told by Mr. *Huygens* in his *Dioptrics*, p. 227; where he ſays, that he ſaw in ſuch an Eel four young Eels (for they are entirely tranſparent) and that after having kept the old Eel a little longer in the Glaſs Tube, the four young ones were obſerved ſwimming by their Dam.

And if this Contemplation alone may have ſo much Power over them, as to force them to confeſs, that an over-ruling Wiſdom prevails in all theſe Matters; the Smallneſs and innumerable

Multitude of theſe Objects in which its wonderful Operations appear, will eaſily convince them, that there muſt be ſomething Divine therein; and it may ſerve at the ſame time to illuſtrate that great Article of Chriſtianity, namely, *That even the moſt minute Things cannot by their Smallneſs eſcape the Direction and Providence of the great Creator.*

SECT. XXIV and XXV. *The Hand of God particularly manifeſted in the Uſe of theſe ſmall Parts.*

LET not then any Infidel who only reads the Bible to form Objections againſt it, imagine any longer that it was almoſt an incredible Hyperbole uſed by the Saviour of the World, when he was pleaſed to ſay, *Matth.* x. 30. That *the Hairs of our Heads are all number'd:* Since we have ſhewn a Providence, exerting itſelf with Reſpect to thoſe *Animalcula*, that can by no means be compared with one ſingle Hair for Greatneſs; and ſince in one Second of a Minute there are more Particles of Light diffuſed from a burning Candle on every Side (all which, as the Mathematicians know, are moſt exactly governed and directed by the Laws of *Optics*) than there are Hairs upon the Heads of any one Man living, tho' that Perſon had as many Hairs upon his Head as there are People in all the World.

To ſet this Matter in a true Light, tho' it may be very eaſily deduced from the foregoing: It has been ſhewn in *Sect.* XVII, that the Number of Particles of Light that proceed from the Flame of a Candle in one Second, is much greater than a certain Number, the firſt Figure whereof is 4, followed by 43 Noughts, or 40^{43}.

Now Mr. *Leuwenhoek* in his *Firſt Letter*, p. 14. finds that the Number of Men upon the whole

Earth, according to his Calculation, amounts to 13,385.000,000 or $133850^{\underline{6}}$. Now let us compute this Number at above much more than 10 times the ſame, and ſuppoſe it to be $20^{\underline{11}}$.

Now if every Man had ſo many Hairs upon his Head as $20^{\underline{11}}$ (which is much too many) the Number of the Hairs of all Men would be $40^{\underline{22}}$, which as appears, would be no more than a $10^{\underline{21}}$th part of the Particles of Light that proceed from a burning Candle ; ſo that from hence we may conclude with the utmoſt Certainty, that the Son of God far from uſing an Hyperbolical way of ſpeaking, falls much ſhort of the ordinary Operation and Direction of his Providence, how figurative ſoever this Expreſſion may appear to weak Men.

Beſides all this, it may perhaps be an Inducement to an Atheiſt to acknowledge a God, if he conſiders, that this adorable Creator and Governour of all Things has thought fit to ſhew particularly thereby his Godhead and Sovereignty over all his Creatures ; that in order to produce the greateſt and moſt ſurpriſing Events and Things, he oftentimes makes uſe of no other but theſe ſmall Particles, theſe contemptible Atoms or Points, making infinite numbers of the ſame ſubſervient to his wiſe Ends and Purpoſes.

To prove this Experimentally, the whole World may in a manner ſerve for an Example ; for to ſay nothing of the ſmallneſs of thoſe Particles which cauſe Peſtilences and contagious Diſtempers, whereby ſo many thouſand Men are often ſnatched away in a little time (in which therefore King *David* acknowledged the Hand of God appearing after an eminent manner ; 2 *Sam.* xxiv. 14. and which even at this time are called by many *the Gift of God* ;) how ſmall and numerous are the parts of Water, of which above a thouſand times a thouſand Millions are neceſſary to make up one Drop, or one ſingle Hail-Stone equal to the Weight of one Grain? And to how great Purpoſes are they uſed, for which Water would be entirely unfit, if it were not capable of being ſeparated and divided into Particles of *an innumerable Multitude, and of an unconceivable Smallneſs?* How many thouſand Millions thereof aſcend daily out of the Seas and other Streams? How many of 'em float in the Air, and that we may not repeat what we have ſaid before in the *Contemplation of Water,* how many fall down in Rain, how many in Snow, how many in Hail, how many in Dews and Miſts; how many are employed in the Nouriſhment and Increaſe of Plants, and in Drink for Animals; how many in barren Wilderneſſes, and for the Support of the wild Beaſts therein? And muſt it not be confeſſed, that all this depends upon the Diviſibility, and upon the actual Diviſion of Matter into an infinite Number of ſmall Particles.

SECT. XXVI. *Convictions from the Smallneſs of the Particles of Air.*

Now tho' the innumerable Multitude of the Particles of Water only might ſeem ſufficient to convince the moſt harden'd Atheiſt of the Direction of God in thoſe great Events, which tend as well to the Advantage as Puniſhment of Mankind; yet if that can't ſatisfie him, let him conſider the Air in the true State thereof: And if he has any Knowledge of Nature, he will admit it as an indiſputable Truth, that the Subſtance of the Air is a Collection of innumerable Diverſities of ſmall Parts, which acting upon each other, do oftentimes exert ſuch a Power as ſurpaſſes even all Belief. Let him only read concerning this

Matter, the Hiſtories that give us an account of the dreadful Force of Storms and Tempeſts, of Thunder and Lightning: Now 'tis plain, that all theſe terrible Effects are brought to paſs by Particles, which are ſo ſmall, and ſo light, as to be able to float in the Air; and that Lightning particularly finds no Pores of the very hardeſt Bodies ſo cloſe and narrow but what it can penetrate.

We have mention'd ſomething of the Air above in *Sect.* XIII. but which falls far ſhort of expreſſing upon thoſe Principles the Smallneſs and Number of its Parts; and if in one Pulſe or Second of a Minute there do proceed ſo many thouſand Millions of Particles of Fire and Light from the ſmall Flame of a Candle, how vaſt muſt the Number be of thoſe that proceed from greater Lightnings, and how ſmall each ſingle Particle thereof?

SECT. XXVII. *Convictions from the Smallneſs of the Particles of Fire.*

AND for greater Conviction, let him farther add Fire or Light to Water and Air, and he will find not only that the Parts thereof are unconceivably Small and Numerous, but alſo that the Powers of it are moſt Terrible. Not to ſpeak again of Lightning, which is an amazing Inſtance thereof, he who has ever read in *Memoirs*, how by the Violence and Number of theſe ſmall Fire-Particles, Subterraneous Caverns have burſt open, and caus'd Earthquakes; whole Rivers have flowed with burning Matters; Cities and every thing in them, have been deſtroyed; Rocks and Mountains ſplit aſunder, and ſometimes vaſt Pieces of them, which did not ſeem capable of being moved by any human Strength, toſſed up into the Air to an incredible heighth; muſt not he acknowledge that all theſe ſtupendous Effects have been brought to paſs by the moſt minute Particles of Fire, and ſuch as could hardly be conceived for their Smallneſs? That he may ſatisfie himſelf thereof without much trouble, let him only look back to *Sect.* XVI, and conſider what has been there ſaid about it, namely, that from ſo ſmall a Flame as that of a Candle, there proceeds in the Second of a Minute a Number of 41,866 with 39 Cyphers following, of Particles of Fire and Light.

Let him now compare therewith the Flames of Lightning, of burning Mountains, of all the combuſtible Matters in the Earth, ſuppoſing them to be inflamed; that mighty Globe of Fire the Sun, and perhaps likewiſe thouſands of fix'd Stars; and then let him reflect with Amazement, how great an Hoſt of numberleſs Particles of Light and Fire are to be found in the World; for, that no Man living is able to compute the ſame, I believe he will readily agree.

Now ſince this dreadful quantity of Light and Fire-Particles does not ſet the World in a Flame (the Poſſibility of which has been already exemplified in Burning-Glaſſes) it is plain enough that they muſt have been reſtrained by ſome ſuperior Power from making ſuch a Havock and Deſtruction.

And now if a Sceptick is deſirous to ſee, and as it were to feel with his Hands a divine Directi- of theſe Particles of Light and Fire, he needs not Contemplate all the combuſtible Bodies in which ſo many thouſands of 'em lie dormant, and as it were lock'd up and fetter'd till the Time that they are to be put into Operation (which likewiſe proves the Direction of a Superior Power) but let him only conſider the Optical Experiments, which will convince him; that all and every Particle of this vaſt quantity of Light, are ſo ſtrictly bound to certain Laws, that falling upon reflecting or tranſparent Bodies, they are compelled to adapt their Motions to the Diverſity of their Figures, and even to unconceivable Circumſtances; with Inſtances of which, Sir *Iſaac Newton*'s *Optics* abound.

SECT. XXVIII. *Convictions from all the foregoing.*

IF all this be not ſufficient, let a Man who ſtill doubts of theſe great Truths, repreſent to himſelf of what ſmall Particles not only Water, Air, Light and Fire, but even without Diſtinction all other viſible Bodies whatever are compoſed. To begin Firſt briefly with Plants and Animals, which are ſubject to Combuſtion and Putrefaction; what ſmall Veſſels and Tubes through which yet ſmaller Particles of Saps and Juices do paſs, are diſcover'd in the ſame by the help of Microſcopes? (about which Mr. *Leuwenhoek* and others may be conſulted) How many Fat and Oleaginous Parts are to be found in the ſame? (of which likewiſe Candles are made from ſome Animals, an Inch of whoſe Fat is diviſible into ſuch an unconceivable Number of Parts by Inflammation, as we have ſhewn above *Sect.* XV and XVI.) How ſmall and numerous are the Particles which from Putrefaction fill ſuch great Spaces of Air with Stench? How much Water proceeds from thence by Diſtillation? Which in *Sect.* XI. has been ſhewn to conſiſt of ſo numerous and ſmall Particles; and when all theſe, both Animals and Plants, have undergone the utmoſt Corruption, they are changed into a fruitful Earth and Matter; How many Particles, eſpecially if viewed with a Microſcope, might we find in the ſame Earth? Now if we caſt our Eyes farther upon Metals and Minerals, thoſe Glaſſes will likewiſe convince us of the ſmall-caſt our Eyes farther upon Metals and Minerals, thoſe Glaſſes will likewiſe convince us of the ſame Smallneſs of their Parts; and yet more, if they be diſſolved in *Aqua fortis*, and moſt of all if they burn, or tinge the Flame with their Particles.

To make an End: After having read all this, and what more can be met with upon the ſame Subject from other Inquirers, I think we may ſafely affirm, that every thing that is viſible in the World is compoſed of an unconceivable Number of various Particles. Let an Atheiſt therefore repreſent to himſelf this innumerable Quantity of thouſands of Millions, and conſider, *Firſt*, Of how many different Kinds they conſiſt, which are each of a particular Nature. *Secondly*, How many kinds muſt be often made uſe of in the Compoſition of one only Body, as we find by the modern Obſervations of Chymiſts, and others, who extract from every Plant or Animal, Air, Fire, Water, Salt, Spirit, and Earth, in ſo great a Diverſity; how many various Compoſitions they make; how from the ſame Seas and Rivers, Air, Clouds, Winds, Sun, Stars, Trees, Shrubs, Herbs, Flowers, Fruits, Bodies of Men, and other Animals, ſuch as Birds, Fiſhes, Beaſts, Earth, Sand, Stones, Metals, Salts, and a thouſand other Things, that have each their Singularities and Properties are produced. *Laſtly*, How, only by the Diſpoſition of the Particles and Atoms which are in themſelves inviſible, this Great, this Wonderful Univerſe is maintain'd in its State and Condition, and all Living Things are preſerved.

SECT. XXIX. *Great Bodies are for the moſt part divided at firſt into ſmall Particles, before God is pleaſed to make uſe of them.*

AND that we may ſee how often the wiſe Director divides great Bodies into ſuch ſmall Particles, before He thinks fit to make them become Inſtruments of his Power; let us conſider of how little Uſe and Advantage Water, for Inſtance, would be whilſt it remained Ice, or a great hard and ſolid Body, in compariſon of what it is when fluid, and divided into Millions of Particles: Whilſt it remains Ice, can it ſo conveniently ſupply Drink to thirſty Animals, or Nouriſhment to Plants? Can it bear loaden Ships and carry them through the whole World? Can it aſcend into the Air in order to come down again in Rains and Dews, or render thoſe innumerable Services which Men reap from it when divided into minute Parts?

Whilſt Fire being collected and ſhut up in Turf, Wood, Coals, and other combuſtible Matters, compoſes great and ſolid Bodies, what Effects can it produce in ſuch a State? And unleſs thoſe great Bodies be firſt divided into ſmall Particles and Flame produced by the Motion thereof, can they be any ways uſeful for Warmth, for Light, for melting Metals, for preparing Food, and other neceſſary Purpoſes?

The moſt active Matter that we know of amongſt humane Compoſitions, is Gunpowder: What can it do whilſt it is only Salt-Petre, Brimſtone, and Coals? But when thoſe ſmalleſt Particles of which it conſiſts, are let looſe and put into Motion, what is there in all Nature here upon Earth, and round about us, that can reſiſt its Violence? Inſomuch that even Thunder and

Lightning, which are obſerved to be the moſt terrible Powers in the World, tho' they likewiſe are compoſed of ſuch fine Particles as are capable of floating in the Air, are ſo exactly imitated thereby, that he who ſees the Flame of the former, or hears the Noiſe and ſometimes feels the Earth trembling under his Feet, has oftentimes reaſon to doubt whether it be not really natural Thunder and Lightning which produces thoſe amazing Effects.

We may learn from hence, as from an Experiment made and ſerving only for that Purpoſe, how great the Force of the Particles is, which, as far as our Inquiry can extend itſelf, muſt be eſteemed the moſt minute of all, ſuch as ſimple Fire and Light.

CONTEMPLATION XXVI.

Of Certain LAWS *of* NATURE.

SECT. I. *What a Law of Nature is.*

WE underſtand, by this Expreſſion, nothing more here than a kind of Property or Power producing ſomething in or about Bodies or their Parts, and which may be experimentally proved in certain Circumſtances to have always place in the ſame; but we ſhall not pretend to a deep Scrutiny here, whether they be produced immediately by the Firſt Cauſe, or by Second or Intermediate Cauſes acting in or about them.

SECT. II. *The Laws and Powers of* Coheſion.

IF then we reflect on the inexpreſſible Number and unconceivable Smallneſs of the Particles of Matter of which the Univerſe conſiſts, even the moſt obdurate Atheiſts cannot deny, that Laws are neceſſary in order to produce this beautiful World, and all that is to be found therein. And if every thing were moved by Virtue of mere Chance, working without Rule or Order, (juſt as if little Particles of Duſt were blown by different Winds) no body that is reaſonable but muſt confeſs that he could expect nothing but the utmoſt Confuſion from thence.

The firſt Law or Power then that occurs to us, is, that of *Coheſion*, whereby certain determinate kinds of Atoms are faſten'd to each other, in order to produce together certain determinate particular Effects.

Let then an unhappy Philoſopher tell us, when he ſees ſo many Men, Beaſts, Plants, Heavenly Bodies, and what elſe can be reckon'd among Corporeal Beings, formed with ſo great Regularity and Order by ſuch a *Coheſion* of Parts, whether there be not infinitely more Wiſdom required thereto, than to build a Houſe of the neceſſary Materials of Wood, Stone, Iron, Glaſs, *&c.* ſuppoſing them to be all prepared and brought together for that Purpoſe, and certainly he would not aſcribe this latter to Chance, or the ignorant Laws of Nature only.

Now with how great a Force the Parts of ſome Bodies, ſuch as Flints and other Stones, Diamonds, Iron, and other Metals do *cohere*, is manifeſt by Experience, and particularly from the Violence that is requiſite in many, to ſeparate the Parts from each other. But if any one ſhould object, that this *Coheſion* is only produced by Reſt of the Parts among one another, and that in order to continue Bodies in Reſt, there is not ſo much Wiſdom or Power neceſſary; he may learn from Mr. *Marriotte de Percuſſ.* Part II. Sect. 2. and from Mr. *Huygens*, Sect. 3. that he is miſtaken therein, thoſe Gentlemen having proved, that a Body, how great ſoever, upon the leaſt Percuſſion or ſtriking of another, how little ſoever it be, loſes its Reſt, and is put into Motion; which however is never experienced in hard Bodies, the Parts of which (were they as hard as poſſible) if they only cohered by Reſt, might be blown away and ſcatter'd with the Breath of ones Mouth, like a Heap of Duſt.

Beſides the Greatneſs of this Force of *Coheſion*, it is likewiſe wonderful to obſerve the Variety thereof, by which every thing is and remains adapted to its proper Uſes after a particular manner. Thus if all the Parts of the Tongue cohered, or were ſo ſtrongly joyn'd together as thoſe of the Teeth, it would be immoveable; and if the Teeth were as ſoft as the Tongue, they would not be fit to grind our Food: If the Parts of Corn, and other Meats with which Men and Beaſts are nouriſhed, were as hard, and cohered as cloſely as Iron and Flints, the Earth would be ſoon diſpeopled. If therefore any one be ſtill ſo blind as not to diſcover in the Manner and Variety of Powers of this *Coheſion*, or of the Hardneſs and Softneſs of Bodies, an infinite Wiſdom; why does not he maintain likewiſe (to uſe a courſe Compariſon) that our Beds and Blankets are ſoft, and the wooden Frames belonging to 'em are hard by meer chance, and without the Deſign of the Workman?

SECT. III. *The Laws and Powers of Separation.*

NOW if all the Parts of Matter ſhould be ſubject to no other Laws but only thoſe of *Coheſion*, the World would be filled with all the Carcaſſes of Men and Beaſts, with all the rotten and putrified Plants, as with an odious and loathſome Burthen; and every thing remaining without any Alteration in its Corporeal Figure, would be entirely uſeleſs to many Purpoſes. Now can an unhappy Sceptick obſerve herein no Wiſdom of the great Governour of the Univerſe! Foraſmuch as thoſe very Parts, which in other Circumſtances did before ſtrictly cohere, are compelled to obey other Laws and Powers, and to ſeparate themſelves from each other. By this Means the World is disburthen'd and releaſed from ſo many unneceſſary things, the Parts of which are divided from each other by Fermentation and Putrefaction; and afterwards again ſeveral other Matters are formed thereof, as for inſtance, the moſt fruitful Lands, and many other Advantages do reſult from thence, of which a Multitude of Examples might be given, but we ſhall mention no more here, having already ſpoken of this Circulation of Matter upon other Occaſions.

SECT. IV. *The Unattrition of ſuch fine and tender Particles.*

BUT there's ſtill a Law and Power, which will amaze every one that reflects upon it, namely, That theſe Particles of Matter, ſo ſmall and ſo fine, ſhould have continued for ſo many Ages without *Attrition*, or wearing away; notwithſtanding that they have undergone ſo many *Frictions* or Rubbings, ſo many *Percuſſions* or Strikings among themſelves, or againſt other hard Bodies, beſides Motions innumerable; inſomuch that it ſhould ſeem, that in ſo many hundreds of Years they would have been entirely ground to Atoms, or all their Angles and Corners, being worn away, become round; which Figure Experience teaches us to be the laſt that all Bodies aſſume, before they be perfectly bruiſed or ground away: Who can imagine, that it ſhould be poſſible that the Particles of Fire, after ſuch dreadful and raging Motions among each other; the Particles of Air, after violently ſtriking by Thunder and Lightning, by Hurricanes and Storms, againſt other hard Bodies; the Particles of Water, after ſo many Frictions, for Ages, againſt ſandy and ſtony Beds and againſt Rocks, ſhould ſtill preſerve the neceſſary Forms, were it not that this Law of Unattrition of the ſmalleſt Particles did obtain in Nature? or that others were continually produced in juſt the ſame Number, neither more nor leſs, in the ſtead of thoſe that were conſumed, both which would prove a Divine Providence.

SECT. V. *Two Principal Laws of Nature,* Percuſſion *and* Attraction, *&c.*

FROM theſe Powers we ſhall now paſs on to others, of which there be two principal Ones, and according to the Laws of which moſt Bodies diſpoſe themſelves: The *Firſt* is *Percuſſion,* the *Second* is, by very great Mathematicians of this Age, termed *Attraction*; to which ſome likewiſe are wont to add conſequentially, the Power of *Repulſion.*

Two Bodies are ſaid to ſtrike when one of 'em runs againſt the other, which is at reſt, or likewiſe if the laſt meets the firſt; as alſo when the laſt running ſlower than the firſt, is overtaken, whether the Way along which the Motion happens be in a Right Line or Oblique with reſpect to each other.

We don't here diſpute whether ſome Philoſophers are in the right, in deducing almoſt all Cauſes of natural Appearances from theſe Percuſſions; but that there is an infinite Number of ſuch Motions at all times in the World, is unqueſtionable. Let us only conſider the unconceivable Number of Parts of which Fluids conſiſt, and imagine that many thereof, as Air, Light, Fire, Water, *&c.* are in continual Motion, which could not happen without Millions of Percuſſions againſt one another in an Inſtant: Now if there were no Laws obſerved by them herein, let us think what a Confuſion all things would be in.

Now what theſe Laws are, have been ſhewn by *Wallis*, *Wren*, and *Huygens*; and Sir *Chriſtopher Wren* in particular has proved, that the ſame do experimentally agree with the Things themſelves which Mr. *Mariotte* has thought fit to deſcribe in a diſtinct Treatiſe. Now let an Atheiſt conſider whether it can be without a ſuperior Direction, that ſo many thouſand Millions of Bodies, all of 'em entirely ignorant of what they are doing, ſhould have ſo ſtrictly obey'd the Rules of Mathematicks for the Space of ſo many Ages.

And ſince among theſe Laws that are obſerved in the Percuſſion of Bodies, there are likewiſe found ſuch which may indeed be deduced by conſequence from others that are intelligible; but of which notwithſtanding the Manner how theſe Laws are performed, is incomprehenſible to every one; let an Atheiſt think whether we ought not to conclude from the Incomprehenſibility of the Manner of the Operation, the Incomprehenſibility of the Operator himſelf, and thereby acknowledge a Wonder-working God.

To give an Inſtance thereof here, it is obvious to thoſe that underſtand the Mathematicks (but who can comprehend the *How* thereof?) that a Body in the Percuſſion does communicate not only a greater Degree of Velocity, but alſo a greater Force and Motion to another, than it firſt had it ſelf, and yet almoſt retain all its own: The great Philoſopher for Motion, Mr. *Mariotte*, calls this, in his *Treatiſe of Percuſſion*, p. 153, 154, *a very ſurpriſing Paradox*, and a few Lines below, a *wonderful Thing*; and that he might leave it paſt doubt, proves it experimentally.

And Mr. *Huygens* demonſtrates, in what he has writ upon this Matter, that if one placed a hundred Bodies next one another in Reſt, of which each following was always half as big as the preceding;

ceding; and in caſe the Motion begins from the biggeſt, the Velocity with which the ſmalleſt would proceed, would be 14,760.000,000 greater than the Velocity with which the biggeſt was moved; but in caſe the Motion begins from the ſmalleſt, the Greatneſs of the Motion in the whole will be ſo much the more augmented, As 4,677.000,000 is more than an *Unit.*

Mr. *Whiſton* has transferr'd this from Mr. *Huygens* into his *Prælect. Phyſ.* p. 55. and names the Firſt, *a wonderful Augmentation of Velocity*; but the Laſt, *a more wonderful Augmentation of the Greatneſs of Motion.*

To paſs on now to a ſecond Kind of Powers:

It is ſaid, that the Body A (*Tab.* XXIV. *Fig.* 2.) has an *Attractive* or a *Repulſive Force* (*Vim Attractivem vel Repellentem*) or otherwiſe, that the Body B gravitates to the Body A, when we ſee that another Body B is moved towards, or driven from A, without the Intervention of any other Bodies, which by protruding the ſaid B, may be affirmed to produce ſuch Motion.

A Philoſopher who aſcribes all to *Percuſſion* and *Protruſion,* muſt not think he has a Right to deny the Action of theſe Powers, becauſe he can't comprehend the Manner after which things thus happen; foraſmuch as, according to ſuch Notions, we might reject many things likewiſe which Experience prove really to come to paſs. Who can conceive the *How* of what has been ſhewn to happen about *Percuſſion,* or about the Operations of Light in *Contemplation* XXIV? How many Effects are there in Chimiſtry, as likewiſe in Hydroſtaticks, of which we have not yet been able to comprehend the Manner how they come to paſs? No more than of what has been ſaid in *Contempl.* XXIII. about the Bodies and Roots of Plants, which perhaps would be as hardly admited as this Doctrine of *Attraction* and *Repulſion,* if nothing muſt be believed to be true, but that of which we can underſtand the *How* and the Manner. Thoſe therefore who make other Scruples and Difficulties, may conſult the famous Writings of Dr. *Gregory*, Mr. *Whiſton*, and others, who have illuſtrated the Phyſicks of Sir *Iſaac Newton*, and allow of ſo many of the Arguments which are there uſed to demonſtrate this *Attraction* and *Repulſion*, as they think they fully proved the ſame.

Now to ſhew briefly, that theſe two Powers of Nature are not ſupported by a mere Hypotheſis, but that we ſee by Experience, that one Body is moved towards the other, and one Body driven from another, while no Man has ever yet been able to prove by any ſatisfactory Arguments any ſuch Matter, to the protruding Faculty whereof theſe Effects can be aſcribed: Let thoſe who are not yet convinced thereof, obſerve another Property of Matter, namely, that all Things are *heavy*, or do *gravitate* and *move* towards the *Earth*, or *Center* thereof: After the ſame Manner alſo the Planets are carried towards the Sun, the Satellites or Moons towards their primary Planets; and yet no body has been able to ſhew to the Satisfaction of all, what has been the Cauſe thereof; and even the Arguments that are produced to prove the contrary, do not want their Weight; all which may be ſeen in the Works of the above-mention'd Gentlemen.

That which we have quoted in *Contemplation* XXIV. about *Light*, from Sir *Iſaac Newton*, (which he ſays in his *Opticks*, p. 336, to be incomprehenſible to ſuch as follow the vulgar Hypotheſes) is in *p.* 350 of the ſame Treatiſe ſo accurately ſolved by that Gentleman according to to the Laws of *Attraction*, and confirmed by ſo many experimental Truths, that it would be very difficult, without ſuppoſing an Attraction, to diſcover any probable Cauſes of the ſame; beſides this, Chymiſtry furniſhes us with numberleſs Examples of ſuch Motions in its *Efferveſcences* and Conjunctions of Bodies and Salts, and in its *Precipitations* or Separations of Bodies; both which do plainly repreſent an *Attraction* and *Repulſion.* The Cauſes, if there be any, among the Bodies that are near each other, we ſhall not here inquire into, and even Mr. *Mariotte* ſeems, in his Treatiſe of *Vegetation*, p. 15, to acknowledge ſuch a Motion, which he calls a *Motion of Union*, and ſeems to underſtand thereby ſomething analogous to this *Attraction.*

SECT. VI, and VII. *Gravity and its Effects.*

To come to the Particulars of ſome of theſe Laws of Nature:

One of thoſe Appearances of Nature which are ſo familiar to us, that it is daily look'd upon by the moſt ignorant Men without any Surpriſe, namely, the *Gravity* of all Bodies, has often occurr'd to me as an irrefragable Proof of a Wiſe, Powerful and Gracious God, and let him who has not yet been convinced by any other Arguments, ſeriouſly reflect with himſelf, whether it could have happen'd by mere Chance, and without any Deſign, that every thing which we call a Body, and which is to be found here upon Earth (for we ſhall not now take any notice of thoſe things that are beyond it) falls, or is driven down with a certain Force, and by the ſhorteſt Way towards the Center of the Earth; and even when hinder'd by a reſiſting Power, or any other invincible Obſtruction, ſtill preſſes thitherwards, and ofttimes with ſo great a Violence, that we ſee the Floors of Chambers, when loaden with too great

Burdens, and even whole Houſes, ſink down thro' the Force of ſuch a Preſſure.

And thoſe who would deduce all theſe Effects from the Laws of *Percuſſion* only, muſt at leaſt be convinced hereby (ſince ſuch Preſſures cannot be deemed compleat Motions) that there are other Laws that obtain in the World, and other Powers operating, than only thoſe Percuſſions which proceed from *Local Motion.*

Particularly, that we may be convinced of the Direction of a Divine Providence, let us conſider, *Firſt*, What great things are brought about upon the Earth, by this ſimple Law of Gravity. By this alone it happens that the Globe of the Earth continues in its firſt State, and remains hanging upon its Center as upon nothing; that the Sea remains hanging upon its Bottom which is heavier, and furniſhes Men with all thoſe Conveniencies we have formerly mention'd; by this Gravity Rivers flow, which would otherwiſe ſtand ſtill and be turn'd into putrifying and ſtinking Lakes; by this the Rains, Dew, *&c.* deſcend from the Clouds, and moiſten the Earth, cauſing it to bear Fruits for the ſupporting the Lives of Men and Beaſts, and providing Drink for all Creatures: 'Tis by this Gravity that Boats and Ships can ſail upon Rivers and Seas, and that thoſe Waters are diſpoſed and rendered proper to bear vaſt and heavy Burdens upon their Backs; and whereby the Art of Men does produce ſo many agreeable Fountains and charming Caſcades that adorn the Gardens of Princes, and cauſes Brooks to run from Mountains, and Pumps to raiſe Water, and innumerable other Uſes, that are owing only to the Gravity of Water: 'Tis this that cauſes Fire and Smoak to mount upwards into the Air, and puts in Action the Elaſtic Powers thereof, which, if the lower Air were not preſſed by the Weight of the upper, would, after having once dilated it ſelf, remain ſo, and then all things breathing would be immediately ſuffocated, even the Fiſhes, as we have ſaid before, could not continue under Water without dying; nor could one only Particle of Water (of which there are ſo many Thouſand in one ſingle little Drop) aſcend into the Air when the ſuperior Preſſure were removed; as alſo the Water kept up in the Clouds, being at once ſuddenly poured down, all Rain and Dew would ceaſe from thence forwards; and thus this beautiful Globe of the Earth, together with Men, Beaſts, Trees, Flowers, and Herbs, would be abandon'd to a general Deſtruction: And if we were to reckon up all the Uſes of *Gravity*, any one that is but the leaſt verſed in natural Inquiries, muſt be convinced, that it is no Hyperbole to ſay, that they would fill a whole Book.

SECT. VIII. *Heavenly Bodies gravitate towards each other.*

BUT it is aſtoniſhing, what modern Obſervations have render'd very probable, namely, That this Natural Law of Gravity extends itſelf thro' the whole viſible Univerſe, and ſeems to prevail over all, even over the great Heavenly Bodies, which gravitate towards each other in the ſame Manner as the ſublunary Bodies ſeem to tend here with us to the Center of the Earth; upon which Foundation the whole Phyſical Syſtem of Sir *Iſaac Newton*, who ſeems to be chiefly followed by the great Men of this Age in many things, is built. But I don't here undertake to found my ſelf upon the bare Opinions of any Philoſopher, foraſmuch as they are often contradicted by others, ſo long as the Experiments are not only not unconteſtably, but likewiſe not ſufficiently known; I ſhall therefore only endeavour to repreſent ſome few of thoſe things that appear true by Experience, for the Advantage of thoſe for whom we are here writing.

It is plain, by Experience, that all Bodies being once put into Motion, purſue their Way in one and the ſame Right Line, if they do not meet with any Obſtruction, nor are turn'd out of their Way by another Power; ſo that whatever is moved circularly, as in *Tab.* XXII. *Fig.* 1. the Stone A in the Sling S A, being let looſe, will purſue its Way according to the ſtrait Line A F which touches the Curve A H D E.

Now it has been proved by Obſervations, yea and admitted too, without any Diſpute, by the moſt, if not all the modern great Aſtronomers, that the heavenly Bodies, as A, (*Tab.* XXII. *Fig.* 5.) which they call the Planets, move about the Sun S, in a Curve Line A H D Z, which is not circular, but what the Mathematicians call an *Ellipſis*, at leaſt comes very near to it.

And again it is plain, by what has been ſaid, that a Planet being in any Point, ſuch as A G, *&c.* of this Ellipſis A E D Z, would purſue its Way according to the Right Lines A F or G I, which touch the Ellipſis at A or G, and ſo would entirely forſake the ſaid Curve Figure, which it deſcribes, were it not that another Power did continually cauſe it to approach or incline toward the Sun S, whoſe Force repreſents the Lines F G and H I, ſo that we ſee, that from the Courſe of each Planet a plain Proof may be brought, that there is an active Force that attracts it every Inſtant to the Sun S.

Laſtly, Experience teaches us, that the ſame Power of Inclination obtains not only in the great Planets that move about the Sun, (*Tab.*

XXII. *Fig.* 1 and 2) with reſpect to the ſaid Sun, but likewiſe in their *Satellites* ; for Inſtance, in thoſe of *Jupiter* F, and *Saturn* H, in relation to the ſame Planets, ſince theſe are commonly attracted to their primary Planets, after the ſame Manner as thoſe Planets are attracted to the Sun, or exert a Motion by their Gravity towards the ſame.

SECT. IX, and X. *A ſtrong Proof that the Heavenly Bodies gravitate towards each other, and Convictions from thence.*

BUT beſides all this, I muſt not paſs by a Remarkable Obſervation related by Mr. *Whiſton*, *Prælect. Phyſ.* p. 289. who ſhews experimentally, that beſides this Gravitation or Attraction between the Planets and the Sun, and between the *Satellites* and their Primary Planets, there may be viſibly diſcover'd the like Attraction between one Planet and the *Satellites* of another. Theſe are his Words, ſo far as they relate to this Matter.

For as Saturn H (*Tab.* XXII. *Fig.* 1 and 2) *remained ſome Years ago a long Time about its Conjunction with* Jupiter, F, (*that is, when* Saturn *and* Jupiter *are at the neareſt to each other, and we ſee from the Sun* S, Saturn *at* V, *and* Jupiter *at* F, *in, or almoſt, in a ſtrait Line*) *and conſequently it muſt neceſſarily follow, that* Saturn, *by reaſon of the Greatneſs of its Body and its Nearneſs to* Jupiter, (*for it is by both theſe that the Force of Attraction is regulated according to Mr.* Whiſton) *muſt occaſion ſome remarkable and viſible Effects in the* Satellites *of* Jupiter ; *if that Planet with its* Satellites *be attracted to* Saturn ; *and ſo the Matter is really found to be, and the* Satellites *of* Jupiter *do change their uſual Courſe in this Nearneſs of* Saturn *agreeable to the ſaid Law of Attraction.* So that even the ſo juſtly eſteemed Aſtronomer Mr. *Flamſtead*, who would not at firſt allow of this Attraction in the Heavenly Bodies, after having made the moſt accurate Calculations, did frankly confeſs, that this Law does likewiſe obtain among them in full Perfection.

Now let any one who hitherto has doubted of God's directing Power in the World, judge from theſe Experiments, whether there be not a wonderful Force acting upon theſe vaſt Globes (whoſe Magnitudes are not wont to be meaſured by Feet, Fathoms or Miles, but by whole Diameters of the Earth; and whereof one, namely *Jupiter*, contains 8000 of the ſame) which Power ſo violently protrudes thoſe Bodies without any Inſtruments, that no Cannon Bullet can be compared to the ſwiftneſs of their Motion; and at the ſame time does ſo direct the manner of theſe violent Motions likewiſe, without uſing any viſible Means, that they are obliged (in ſpight of the unconceivably ſtrong Efforts, which they inceſſantly make, to fly out of their Orbits,) to obey the preſcribed Laws of *Attraction* or *Gravitation* towards each other in every the ſmalleſt Point of their Way; and thereby to determine their Motion within ſuch narrow Bounds, even ſo far, that theſe Planets at a greater Proximity to each other, do by the ſame Laws continually depart farther from each other, and ſo render an Obedience thereto according to the moſt exact Rules.

Finally, After all this, let the unhappy Atheiſt conſider, ſince all theſe Heavenly Bodies are driven or attracted with ſo dreadful a Force towards each other, whether it happens without Wiſdom, that they having for ſo many Ages moved according to theſe Laws, have not at ſome time or another fallen foul or ſtruck againſt each other in ſuch a manner, as to burſt in a thouſand Pieces; the rather, becauſe even ſome of the principal Mathematicians maintain, that it is poſſible that notwithſtanding the regular Motions aſcribed to the Comets, they may yet run againſt the Globe of the Earth, and ſo produce a Percuſſion between two ſuch ſwiftly moving Bodies, which no Body can think upon but with Terror: But of this laſt ſort of Heavenly Bodies, ſince we know ſo little of 'em, excepting what is liable to Diſputes, we ſhall make no farther mention here. This is certain, that unleſs an Atheiſt does abſolutely deny his own Principles, and allows that an unconceivable Wiſdom and Power working without viſible Means, has place in the World, he will live in a continual fear, that the like Misfortune may befal the Earth upon which he dwells: For that theſe Laws according to which ſuch great Bodies, none excepted, do continually endeavour to approach each other, can be aſcribed to any other Cauſes than merely to the Will of the ſupream Director, does not ſeem to me to have ever yet been proved by any Body.

SECT. XI. *The Operations of Gravity in Bullets and Bombs.*

NEITHER Time nor Place will permit us to produce here any more of all thoſe Arguments from *Mechanicks* or the *Science of Motion*, by which we could ſtrongly prove a directing Wiſdom, ſince all the Motions of Bodies running againſt, or among each other, even to the very ſmalleſt, are found to obſerve certain Laws, which could not proceed but only from an Underſtanding and Powerful Being, ſince they are regulated according to Reaſon and Judgment.

The aforementioned Gravity ſeems alone to give ſufficient Proofs thereof in thoſe Things which are every where obſerved among us upon the Superficies of the Earth.

And for greater Confirmation, what is there in the World more Untractable, more Ungovernable, than the Motion of the Parts of Gunpowder when 'tis ſet on Fire? And who could have imagined that thoſe Motions in the diſcharging of Bullets from Guns, and toſſing of Bombs from Morters, do always obſerve the Laws of Gravity preſcribed to them in their dreadful Force and Swiftneſs, with ſo much Accuracy and Niceneſs, as to become on that very account the Objects of the Mathematicks? And yet we ſee that they don't move one Point forwards without continually obeying the ſame in their ſo ſwift a Courſe. And this Experience is even proper from whence to form fixed Rules in Gunnery and Bombarding, whereby Bodies protruded with ſo unexpreſſible a Force, in a Courſe ſo ſwift, as hardly to be reſtrained by any Powers, can be ſo exactly determined and regulated by the Deſign of Men, who have ſtudied the Laws to which they are Subject, as to be made to fall upon, or ſtrike any particular Place, provided the ſame be within their reach.

SECT. XII. *The Operations of Gravity in the* Catenaria *or Chain-Curve.*

WE could here produce numberleſs Caſes in which it may be proved, that not only thoſe prodigious flying Globes, ſuch as Cannon-Bullets and Bombs, of which we have already ſpoken, but likewiſe thouſands of Millions of others, and of the ſmalleſt Bodies, do deſcribe Geometrical Curve-Lines, wherein the Property of the Line, according to all the Laws of Mathematicks, is preſerved in all its Points. Thus there run many thouſands of Water-Particles out of the ſpouting Pipe of a Fountain, and not one of 'em ſhall tranſgreſs the

Line which the Mathematician can ſhew that it ought to deſcribe in thoſe Circumſtances. What Honour did that great Mathematician *Leibnitz* acquire, by ſhewing that he had attain'd to a perfect Knowledge of the Curve-Line A C B, *Tab.* XXIV. *Fig.* 3. which is produced by the Gravity of the Parts of a Chain or Rope, faſten'd to two Nails A B? And how much Eſteem and Credit has it given to Dr. *Gregory*, to have been the firſt Diſcoverer of ſome new Properties of the ſame? How many Mathematicians have in vain turned all the Powers of their Mind towards theſe Diſcoveries, who notwithſtanding that they ſufficiently knew the Properties of Gravity, which was the only true Cauſe thereof; yet are forced to own, that they were unable to deſcribe rightly upon Paper the *Catenaria* or Chain-Line, for ſo the abovesaid Curve is named? And who can contemplate without Aſtoniſhment, how nimbly the ignorant Parts of which this little Chain conſiſts, do diſpoſe themſelves by their Gravity into that Order, which is requiſite to produce the ſame? And thus we might give many more Examples of the ſame Nature.

SECT. XIII. *There can be no Ignorant Neceſſary Firſt Cauſe deduced from a Series of Ignorant Cauſes operating together.*

I KNOW very well, that thoſe who ſet themſelves as much as poſſible againſt a Knowledge of God reſulting from the Creatures, will anſwer, that theſe Laws of Nature, according to which all theſe Things happen, and this Diſpoſition of the Parts of the *Catenaria*, this Motion of Fountain-Water in its Courſe and Line, this Direction of Bullets and Bombs in their Flight are always neceſſary, and that it would be impoſſible it ſhould happen otherwiſe; and this they maintain to be the Reaſon that thoſe Mathematicians who argue juſtly, can draw Concluſions agreeing with the Premiſes.

For Inſtance, it is known that there is a Law in Nature, that in caſe two Powers do equally act upon a Body A (*Tab.* XXIV. *Fig.* 4.) of which one acting in the Direction to A K, and the other according to A L, (and move the ſaid Body) that as the one or the other is more or leſs Violent, that Body will be moved according to different Lines A D, A E, or A G, which are found and determined by drawing a Diagonal Line in the Parallelogram A B E F, A H G C, the Sides of which conſiſt of the Lines along which the Body would be moved by each particular Power in the ſame time, as here A B and A F, or A H and A C; from whence it then follows, that if in a Minute, or more or leſs time, the Body A ſhould be moved by one Power from A to C, and by another Power from A to B; that the ſame Body A, by the Action of theſe two Powers, would equally in one Minute be protruded, according to the Line A P, the Length A D, which is the Diagonal of the Parallelogram A B C D.

But in caſe the Firſt Power could move the ſame not from A to C, but to F in one Minute; and the Second Power remained the ſame, it might deſcribe the Line A E in a Minute: In the like manner alſo for the ſame Reaſon, if the Second Power that protrudes it towards A L were greater, and could carry the Body in a Minute from A to H, if the Firſt remained unchangeable according to A C, by both the Powers together the Body A might in one Minute run the Space from A to G along the Line A G.

From which Principles, Sir *Iſaac Newton* has ſhewn briefly in his *Princip. Philoſ.* p. 14, and Mr. *Varignon* more largely in his *Nouvelle Mechanique*, that all the Laws of Motion, and the Rules of Mechanics do neceſſarily flow, and have given Inſtances thereof in all the Mechanical Powers.

It is likewiſe known, that the Flight-Line of a Bullet diſcharged from a Cannon, (*Tab.* XXIV. *Fig.* 5. A D E F G) is determined merely by this Law of Nature; foraſmuch as there are every where two Powers acting upon it, *viz.* one, which being produced by the force of Gunpowder, does continually impell it from A to K; and another, that of *Gravity*, which cauſes it to deſcend continually by the Lines A B, D L, E M, *&c.* which are at Right Angles with the Horizon.

SECT. XIV. *The Firſt Motion proves a God; as does alſo the* Continuation *and* Communication *of* Motion.

SINCE the Philoſophers, whom we are endeavouring to convince, are wont to inquire into, and to prove the immediate Cauſes of all Things from their Effects or Operations only, why do they not more ſeriouſly endeavour to aſcend to the firſt Cauſe of all Things? They find that the moſt, if not all the Appearances in Nature that have been hitherto known, are cauſed and brought about by Motions; whether we may call them Protruſions, or (with ſome other great Men of the preſent Age) *Attractions* or *Repulſions*; they inquire what Laws of Motions muſt follow from either *Percuſſions* or *Attractions*: Now let them extend their Studies to the Cauſe that firſt produced theſe Motions, and immediately the Power of a Deity will appear to them from Mathematical Concluſions, eſpecially if they will pleaſe to Reflect upon what Experience has taught them and all Mankind; namely,

I. That a Body may be put into Motion, and may likewiſe be at Reſt, or ceaſe from Motion; and that in both thoſe Caſes it will remain a compleat Body, and preſerve its Exiſtence.

II. It follows from thence, that Motion does not belong to the Being of a Body.

III. Whereupon it may be here obſerved, that the famous Sir *Iſaac Newton*, and the Commentator upon his Arguments and Demonſtrations, Mr. *Whiſton* in his *Prælect. Phyſ. Defin.* I. p. 25. (we Inſtance in both theſe Gentlemen, becauſe no Body will diſpute them the Title of very great Mathematicians) have rightly deſcribed or defined a *Body* to be an extended and ſolid Subſtance, not only indifferent to Motion and Reſt, but likewiſe without any Power in it ſelf, and ſimply Paſſive (*Subſtantia Iners & Paſſiva*) of which Mr. *Mariotte* gives a Proof by ſeveral Experiments, in the *Fifth Propoſition of his Treatiſe about Percuſſion*, p. 31. ſhewing that how much more ſolid a Body is, that is to ſay, how much more of Corporeal Matter it contains within the ſame Space, ſo much greater is the Reſiſtance which it makes againſt Motion.

IV. So that from all this it is eaſie to conclude, that no ſuch Thing as a Body can be the firſt Cauſe of thoſe Motions, which neverthleſs we find to obtain among Bodies.

What can then follow, ſave only that the firſt Cauſe thereof muſt be Incorporeal, and even wonderful and unconceivable in his Operations, foraſmuch as not being a Body himſelf, he is able to move all Bodies.

Who is likewiſe the firſt Cauſe of every Thing that happens in the World, in which every Thing is performed by Motion; who is a Cauſe working freely, and according to his own good Pleaſure without any Neceſſity; becauſe, tho' Motion cannot be made without a Body, yet a Body exiſting, it cannot be proved by any Conſequence that it muſt neceſſarily move; ſo that if it be endowed with Motion, the ſame muſt be deduced from a Cauſe operating without any Neceſſity.

Now this Cauſe muſt be infinitely Powerful, to be able to frame an Edifice of ſo vaſt an Extent as the Univerſe is, and to move ſuch mighty Bodies as the Planets with ſo great a Velocity as has been ſhewn above; he muſt likewiſe be infinitely Wiſe, ſince he is able to direct the Motions of numberleſs great and ſmall Bodies to ſuch glorious Purpoſes. This I think no Body who underſtands what has been already ſaid can deny with more Reaſon than he can ſtifly maintain, that a Ship can ſail without a Rudder; that a Watch can ſhew the Hour without a Hand; that a Bell can ſound without a Clapper, and ſo of many other Machines, that they are made without any Deſign. Now in all Matters where we can diſcover a determinate End and Purpoſe, it muſt be confeſſed, that a wiſe and underſtanding Being is concerned in the framing of them, ſince nothing that has no Knowledge can propoſe any End to it ſelf. *Finally*, this Cauſe muſt be infinitely good, ſince by ſuch Motion it imparts Life and Breath to all Animals, and beſtows numberleſs other Benefits.

Beſides all this, ſince it is here ſuppoſed that we have to do not only with a Sceptical Philoſopher, but likewiſe with a Mathematician too, and who conſequently in order to ſupport the preceding Objections, thinks himſelf capable to ſhew how the Laws of Motion may by a perfect Neceſſity be deduced from each other without any Divine Direction or Original; we intreat this Diſputer, that he would only recollect the firſt

Axiom, without which all Mathematical Argumentations would be in vain, and which therefore Mr. *Whiſton* terms the moſt Fundamental of all; in his *Prælect. Phyſ. Mathem. Axiom the* 1. p. 41, and which likewiſe *Wallis* in his *Mechan. cap.* 1. *Prop.* 11, 12. *Huygens, Newton, Keil* and *Mariotte* (which laſt has endeavoured to render the ſame more plain by a particular Experiment) and many others have laid down for the Foundation of Mechanics, it is briefly this:

A Body being once at Reſt, or in Motion, ceaſes not from that Reſt, or from being moved in a Right Line with the ſame Force, and without any Augmentation or Diminution thereof; unleſs another Force acting upon it produces a Change therein.

This is allowed by every one, when a Body is at Reſt, but when in Motion 'tis doubted by many unexperienced Perſons; but ſince our Philoſopher is ſuppoſed to underſtand Mechanics, he muſt be likewiſe convinced of the Truth of this Law of Nature, ſince a great Number of Experiments have been made in Machines to confirm the ſame, by which this Law is with ſufficient Certainty proved *a Poſteriore.* And it will plainly appear to him whom we ſuppoſe to have read the Writings of great Men, what Pains they have taken in ſeeking after a ſatisfactory Cauſe of this wonderful *Phænomenon*, which will therefore be unneceſſary to mention here; and that ſome of 'em have aſſerted in expreſs Words, that the Almighty GOD is the only Cauſe thereof. See *Keil's Introduct.* p. 118.

And if he ſtill retains his Doubts, let him conſider the following Law of Nature, according to which it has been allowed and experienced by every Body, *that the Motions, and all their Differences and Changes in all Bodies are greater and ſmaller in Proportion, as the Powers which impreſs the ſame into thoſe*

thoſe Bodies are greater or ſmaller. According to this Argument produced by moſt, that all Effects are proportionable to their adequate Cauſes: See *Wallis Mechan. cap.* 1. *Prop.* 7. So that if one certain Force cauſes one Motion, the ſame being doubled will cauſe a double Motion, a triple Force, a triple Motion, and ſo on.

And let him ſuppoſe, that if a Man in the beginning of the World, or four or five hundred Years ago, had laid a little round Marble upon a Table, and to put the ſame in Motion had given it a Fillip with his Finger; the ſaid Marble, according to the abovemention'd Law of Nature, would (if no other Force had oppos'd its Motion) have moved to this very Minute with the ſame Velocity in a Right-Line, and without ceaſing, would have continued to run in the ſame Line ſuch a Length, as no Man could determine the end of.

He knows that this is no vain Opinion, but, as we have fully ſhewn before, a Law of Nature really obtaining in moved Bodies, confirmed by very many Experiments, and upon which almoſt the whole Science of *Mechanics* and *Percuſſions*, particularly the Properties of *accelerated and retarded Motion* are founded; Examples of which may be met with in the Demonſtrations of the *two firſt Propoſitions of the Mechanics* of Dr. *Wallis.*

And let him farther conſider with himſelf, if no Divine and Incomprehenſible Power had place herein, which cauſed the Continuation of this Motion, and which obliged all Bodies continually to obſerve a Law, that otherwiſe was neither to be believed nor underſtood; whether he could imagine that the ſmall and contemptible Force communicated by the Fillip of a Finger, could be the adequate Cauſe of ſuch a Motion, by which this little Body can exceed in its Courſe all the

Bounds that he or any Man living is capable of preſcribing to it, without any loſs of its Force and Velocity; and whether any one beſides himſelf would ſay, that this ſo great an Effect can be accounted proportionable to ſo mean a Cauſe as the Fillip of a Finger; and if this does not ſatisfie him, if he be a Mathematician, he muſt know *firſt*, that no Body can be ſo ſmall, or move with ſo little Force, but that ſtriking againſt another, (which is at Reſt, and has no Obſtruction) how great ſoever this laſt may be, it will move it, and cauſe it to run forwards in a ſtrait Line, ſo that both of 'em will proceed with equal Swiftneſs; tho' ſuch Swiftneſs will be ſmaller than that which the firſt moved Body was endowed with alone. (See beſides, concerning this Matter, *Wallis his Mechanics*, Ch. XI. *in the Scholium*, Sect. II.)

So that from hence it follows, that when a little Body, not ſo big as a Marble, but ſo ſmall even as the fineſt Grain of Sand, being protruded by the Fillip of a Finger, runs or ſtrikes againſt another Body, which we will ſuppoſe to be as big as the whole Globe of the Earth, or if you will, thouſands of times yet bigger (provided that neither of 'em be Elaſtical, and conſequently rebound from each other) this great Body will not only be protruded together with ſuch a Grain of Sand according to a Right Line; but unleſs ſome oppoſing Force or Obſtacle do intervene, and hinder the aforeſaid Motion, the great Body, as well as the little Grain of Sand, will by the Force of this Fillip, continue to be moved according to the ſaid Line inceſſantly; and if they were to meet in their Way with a hundred thouſand of other Bodies, and each of them were a Million of times bigger than the Earth, they would carry them all along with 'em in Conſequence of this ſmall

Force, without any ones being able to determine how far.

Now that this, how wonderful ſoever it appears, is certainly true, no Mathematician can deny; but let this Sceptical Philoſopher, who hopes by the neceſſary Deductions of one Law of Nature from another, to elude the Providence and Intervention of a God; I ſay, let him ſhew us from his Principles, whether he can any ways comprehend, not that ſuch a Thing actually happens (for this the Mathematics will teach him) but how, and after what manner this Force of a little Grain of Sand ſo moved does act; ſo that any Percurſſion thereof does not only protrude ſuch unconceivable great Bodies with any Force, but likewiſe can continue the Motion of them without ceaſing for thouſands of Ages: And it has been long a queſtion in Phyſicks, *How the Motion of one Body is communicated or transferr'd to another?* which as far as I know, has never yet been rightly anſwered by any.

Then in caſe he could make no other Reply thereto, than that both the *Communication* and *Continuation* of Motion, is ſomething which indeed he ſees daily happening, and in the ſame Caſes; but that yet the moſt internal Eſſence of Motion is not ſo well known to him, as that he ſhould be able to ſay, after what manner it paſſes from one Body to another; and notwithſtanding what is accounted the viſible Cauſe (as the Fillip, which in this Inſtance produced ſuch a Motion in the Sand) has long ceaſed to exiſt; yet the Effect may laſt not only in its Form or Being, but likewiſe in the ſame Force, ſuch a Number of Years as no Man is able to determine; for to ſhew the Greatneſs thereof, it is well known to thoſe that underſtand Mathematicks, that according to this Law, a ſix and thirty Pounder being protruded out of a

Cannon by the Force of the Gunpowder inflamed, would continue its Motion with the ſame Strength and Swiftneſs for thouſands of Years, unleſs hinder'd by ſome other Force, notwithſtanding that the Flame of the Gunpowder had ceaſed long before: Will he not then even by this his own Anſwer be compelled to acknowledge, that here, as before in the Motion of the Body itſelf, there is likewiſe an incomprehenſible Power operating in the *Communication* and *Continuation* thereof?

SECT. XV. *The Reaſons produced by ſome for the* Continuation *of Motion, ſeems too weak.*

I KNOW very well, that ſome great Mathematicians who even confeſs that they can ſhew no Cauſe of this laſt Phænomenon of Divine Power, which maintains every Thing in its Exiſtence, and by Conſequence likewiſe this Motion of a Bullet in its Continuation, to Illuſtrate the Matter, affirm, that a Bullet being once put into Motion will always remain ſo; juſt as a Square, and a Globular Body will always retain the ſame Figure; but I hope I ſhall be excuſed by them, if notwithſtanding all the Eſteem which I have for their Learning, I here add, that this Compariſon, tho' produced with the beſt Deſign, which is to acknowledge God for the Cauſe, ſeems to me ſomewhat too weak, and not ſufficiently Analogous and Proper: Since, *Firſt*, tho' a Body being once turned from a Square into a Globular Figure, tho' it remains of itſelf Globular, yet the laſting Operation of the Globular Force does entirely ceaſe: Whereas on the contrary, a Body that was once Still, and at Reſt, being put into Motion, the laſting Operation of ſuch moving Force will fully remain. *Secondly*, Since a Body cannot move of it ſelf, being according to the Deſcription of thoſe Gentlemen *a ſluggiſh Lump of Matter*, and all Motion ſeems to require a Force which continually produces it; foraſmuch as we ſee ſuch dreadful Strength and Violence exerted by a Body once moved (as for Inſtance, by a Bullet ſhot out of a Cannon) which whilſt it remained motionleſs, could not exert the leaſt Force: So it ſeems to be a neceſſary Conſequence, that a Body that has continued already a thouſand Years in Motion, ſhould not retain the ſame Motion for a thouſand Years following, without a Power acting upon it, and producing farther Motion; whereas in order to retain a Circular Figure, there ſeems no farther Force to be neceſſary, than that a Body ſhould at firſt aſſume ſuch a Figure.

Nor is this oppoſed by any Mechanical Experiments or Rules; by which it plainly appears, that one Body running againſt and ſtriking upon another, which other is at Reſt, both of 'em will continue moving with equal Swiftneſs in a Right Line, till ſome other Power ſhall cauſe a change therein; but it is not maintained nor demonſtrated, that with the Continuation of this Motion the Power that protruded the Body, does not remain conſtantly acting.

Now which ſoever of theſe be true, it is ſure enough; 1. That this Communication and Continuation of Motion are both obſcure and entirely unconceivable, as to the manner of their Production. 2. That they are the Foundation of every Thing we are taught in Mechanics, and of all that happens in the World; inſomuch, that nothing can ſcarce appear plain either in Mechanics or Phyſics, to ſuch who have not inquired into the Laws thereof.

SECT. XVI. *GOD acts Reaſonably, Incomprehenſibly, and according to his own good Pleaſure.*

I LEAVE it now to the Judgment of an Atheiſt himſelf, whether he muſt not confeſs and allow;

I. That there is a Power acting in Nature after a manner not to be comprehended by him, tho' the Effects are obvious to every one.

II. Whether all Things are not brought about in the ſuppoſed Caſes by meer natural and ignorant Bodies, according to the moſt ſecret Methods of the Mathematicks.

III. And conſequently, whether there does not then appear a Power in this Univerſe, which acts not only Incomprehenſibly, but likewiſe Rationally, that is to ſay, according to Laws reducible to right Reaſon, or otherwiſe in ſhorter Words, whether he cannot diſcover a God in all theſe Things; who to the end, that he may be found not only by thoſe that ſeek him in his Works, but likewiſe by ſceptical and irreligious Philoſophers too, has impreſſed clear and manifeſt Tokens of his Incomprehenſibility, and conſequently of his Greatneſs upon the Origin of Phyſics, and the very Laws of Nature; to the end that an Inquirer into the Knowledge of Nature, how diligent and penetrating ſoever he may be in many Matters, yet if he be careleſs in this one great Point, may, before he proceeds any farther, be armed againſt this Temptation that has cauſed ſo many to wander and depart from true Knowledge and Wiſdom; foraſmuch, as becauſe they obſerved the Neceſſity of Mathematical Conſequences, and likewiſe that natural Things do always really adapt themſelves according to the ſame, they therefore began to imagine, that all Things come ceeds to preſs with ſo much Violence, according to the ſame Right Line or Direction, that we ſee thereby great Bulwarks, Walls, and the like, overturned thereby; and tho' as many Cauſes thereof ſhould be alledged, as there are particular Hypotheſes, who can prove, that the ſaid Cauſes do neceſſarily reſult from the Nature of Bodies?

So that if indeed we could continually and properly trace them back from Cauſe to Cauſe, we ſhould unqueſtionably find, that the firſt, which is the Spring of all the reſt, acts without any Neceſſity, both as to the things themſelves, as alſo to the Manner thereof.

For which Reaſon, the Wiſdom that appears in theſe Operations, and the Power being joined together, we need not ſearch any farther for a Great, Glorious, and Adorable God; who to the End that every Body might be convinced that the true Original of all things which happen in Nature, is only to be deduced from his infinite Perfections, has depoſited, and does ſtill preſerve the undeniable Proofs thereof, in the firſt Natural Principles of all things.

SECT. XVIII. *The Proof of a God from the Motions of the Particles of Light.*

BUT to turn into the Way again from this Digreſſion, which yet was, in ſome manner, neceſſary to convince ſome unhappy Mathematicians, not ſo much of their prepoſterous Ways, as of their Neglect and Omiſſion in juſtly diſputing concerning the firſt Cauſe of all things; let us then paſs on to other Matters, and produce one Proof, which will appear undeniable to all reaſonable Perſons, of a God directing every thing even to the ſmalleſt Particles and Atoms, as we ſhall ſhew from the Motion of the ſame.

How many Millions of Millions of the Particles of Light do iſſue, in one Inſtant, from the Flame of a Candle? How much, yea, how unconceivably ſwifter are they than a Cannon-Bullet? Concerning which the Reader may conſult the XXIV and XXV *Contemplations*, and if we would ſee how exactly they obey the Rules preſcribed to them, in all their Number and Velocity, let us ſuppoſe the Flame of a Candle at A B (*Tab.*XXIV. *Fig.* 6.) and hold with one Hand a common Spectacle-Glaſs at G L, at a pretty good Diſtance from the Candle, and with the other Hand a white Paper at *f h*, juſt behind the Glaſs, which being carried backwards to *e d*, you will meet with a Place as *a b*, where you will ſee the Light which at firſt appear'd confuſedly upon *f h*, repreſenting perfectly and diſtinctly the Flame of a Candle inverted.

Now we know that this exact inverted Picture at *a b*, is occaſioned no otherwiſe than that the Rays coming from the Point A, and making the Cone A G L, after having paſſed through the Glaſs G L, are all collected at the Point *a*, as thoſe from the Point B at *b*, from C at *c*, and ſo thoſe that come from all the Points of the Flame are all collected in ſo many Points upon the Paper at *a b*, and there croſs each other; for which Reaſon the Pictures or Images, at *f h* and *d e*, remain wholly confuſed; becauſe the Rays coming from a Point of the Candle as A, upon that Place, do fill a large Space, and are mixed with one another, as has been ſhewn before.

This being done, and the Courſe of the Light underſtood, let any Man whatever caſt his Eyes upon this Figure, and obſerve in what a vaſt Number the Particles of Light run, and are mingled with each other, juſt before the Glaſs; ſo that all the Cones of Rays G A L, G B L, G C L, and others that have their Tops or Vertices in each Point of the Flame, as A, B, C, *&c.* (of which there are but three repreſented here, tho' they be numberleſs) do compoſe a confuſed Heap of an unconceivable Number of Particles of Light, at *m n*, before they come from the Flame upon the Glaſs; which Particles run an infinite Number of Ways obliquely and tranſverſly among one another, as they fly towards the Glaſs: Let him likewiſe farther conſider, how many thouſands of Percuſſions will happen in that Place among the ſaid Particles of Light flowing with ſuch an amazing Swiftneſs, and how many of 'em ſeem thereby to be driven out of their Way: In a Word, let the greateſt Philoſopher tell us, whether this Motion of the Particles of Light, among each other, can ſeem to him like to produce any thing but the greateſt Confuſion.

Now if one ſhould endeavour to make an Atheiſt, who had never ſeen this Experiment, conceive all theſe things, and if ſomebody ſhould tell him, that all the Rays proceeding from each Point of the Flame A, B, C, *&c.* tho' mix'd together between *m n*, and G L, having paſſed thro' the Glaſs G L, ſhould again be mingled at the other Side of the ſaid Glaſs between G L and *f h*; and notwithſtanding all this, be afterwards diſtinctly collected in juſt ſo many other Points, *a*, *b*, *c*, &c. in ſo exact an order as to repreſent the Figure of the Flame A B (ſave only that it is inverted) in all its Circumſtances at *a b*, better than the beſt Painter in the World; I ſay if one ſhould tell him all this, would he not look upon it as the greateſt Impoſſibility? But if now one ſhould convince him, that the ſame is experimentally true, and that theſe many Millions of Particles of Light ſo ſwiftly moving among one another, do, without Delay, and after ſuch an amazing Manner, ſubmit themſelves to this Law, as often as any one holds a Glaſs between the Candle A B, and the Paper *a b*, tho' they themſelves are not only entirely ignorant of any ſuch Law, but likewiſe of their own Motions and Croſſings; let him ſeriouſly reflect, whether thoſe Principles upon which he founds his unhappy Philoſophy, can prove to his Satisfaction, that this does happen without the Direction of an Omnipreſent Power, extending its Care over all things, even the ſmalleſt of Bodies.

Let him conſider after all this, whether he cannot diſcover a God herein, who to the End that thoſe that deſpiſe and deny him ſhould remain inexcuſable (at leaſt all ſuch as underſtand the Motions of Light) has been pleaſed that they ſhall never open their Eyes without meeting and receiving an irrefragable Proof of a Wonder-working Deity, which ſo directs and regulates the unconceivable Multitude of all the Rays of Light flowing from all Parts, and mingling among each other, and ſeeming capable of producing nothing but an irretrievable Confuſion before the Pupil of his Eye, as it was before the above-mention'd Glaſs, I ſay, does ſo regulate them all, that they can ſerve for a diſtinct Sight to all Creatures.

SECT. XIX. *The Exiſtence of a God proved likewiſe from the Laws of Mechaniſm in general.*

MOREOVER, all who underſtand Mechanics, or the Science of Motion, know that the ſame in its greateſt Extent, does conſiſt of nothing elſe than Conſequences that are deducible by Argumentation from ſome few natural Laws; and that Bodies wholly ignorant of what they are doing, obſerve the ſame in all Circumſtances with the utmoſt Exactneſs, even ſo far, that before they depart from the ſame, they operate things which to many Men that have not ſeen them ſeem incredible, and to thoſe that have ſeen them, wonderful; Numbers whereof are to be met with in the Books that go under the Name of Natural Magic-Books, and Mathematical-Recreations; but ſince we don't write here only for Mathematicians, we ſhall not produce any Particulars thereof, but only ask thoſe who ſtill doubt, whether upon their Reading a Book of any learned Author, in which are contained the Principles of Mechanics, (for Inſtance, that of *Stevin*, *Wallis*, *la Hire*, and others, who have writ particularly upon that Subject) tho' ſuch a Book conſiſts of Paper, Ink, and other Materials, in which there is neither Senſe nor Knowledge, yet they will pronounce, with great Aſſurance, that it muſt have been writ by ſomebody who was Wiſe and Learned, and that underſtood all theſe natural Laws and their Conſequence.

SECT. XX. *Tranſition to ſome Hydroſtatical Laws.*

BESIDES, the Laws by which the great Director regulates the Motions of Solid Bodies, there are others that have place in Fluid Matters, and which if they do not very much differ, even in the firſt Fundamentals, yet do they ſo at leaſt in the Phænomena, or Appearances, reſulting from thence.

Now ſince we know, *Firſt*, that the greateſt Part of the Univerſe conſiſts of Fluid Matters, ſuch as Water, Air, Light, *&c.* *Secondly*, That all theſe Fluid Matters are heavy, and conſequently produce many things according to the Laws of their Gravity. *Thirdly*, That theſe Fluid Matters are the principal Inſtruments of which the Director of all things does moſtly make uſe. *Fourthly*, Since in this Operation of Fluid Mat-

Page 310.

TAB XXIV

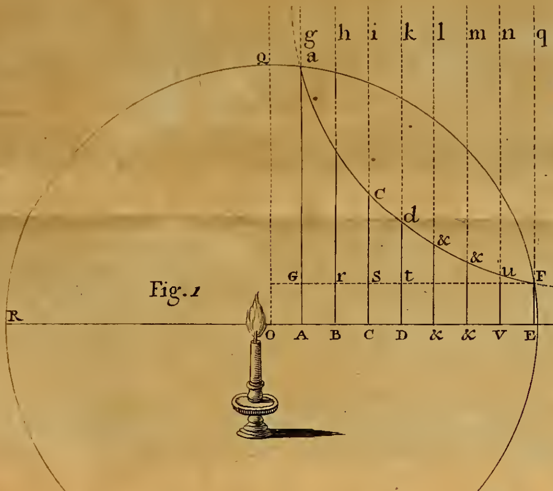

Fig. 1

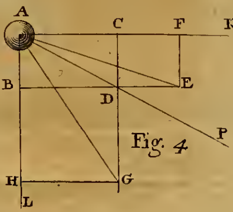

Fig. 4

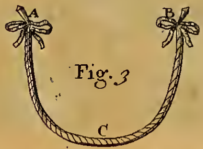

Fig. 3

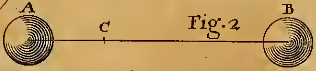

Fig. 2

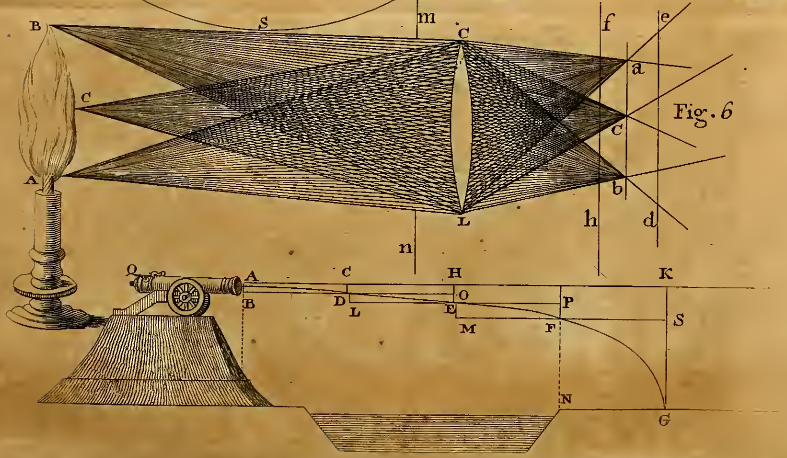

Fig. 6

ters, the Wiſdom, Power, and free Pleaſure of the Creator of the World does ſhine out after the cleareſt manner:

We have drawn up a ſhort experimental Demonſtration of ſome of the ſaid Laws of *Hydroſtaticks*, to the end that when we proceed to ſpeak of the *Law of Preſſure according to the Depth*, which has Place in Fluid Matters, and from thence deduce ſo many Wonders of the great Ruler of Nature, any one may be entirely convinced of the Certainty thereof; which Demonſtrations, thoſe Readers, who think they ſtand in no need of ſuch Aſſiſtances, may paſs by, and go on to what follows them.

Experimental DEMONSTRATIONS *of the Law of the Preſſure of* FLUIDS, *according to their Heighth or Depth.*

SECT. XXI. *General Terms and Poſitions in Hydroſtatics.*

To begin then:

I. As to the Terms of *Liquids* or *Fluids*, we mean here the ſame thing by them, tho' ſome do not allow all Fluid Matters to be properly Liquid. For according to them, the *Air* is indeed a Fluid Matter, but not Liquid, as Water, Oyl, and the like; but for Brevity ſake, we ſhall make no Difference.

II. All the Parts of a Fluid, when at Reſt in a Veſſel which is immoveable, do yield to the ſmalleſt Force acting on them; and ſo yielding, have their Parts eaſily ſeparated, which immediately by their Gravity do again come together. The Proof of which is obvious to every Man's Experience.

III. The Superficies of all Fluids, upon which there is immediately incumbent either another Fluid Subſtance, or nothing elſe that is heavy, or that operates by another Power, will, according to the Action of Gravity, become Horizontal or Level, that is, ſettle itſelf parallel to the Horizon.

In order to ſee ſuch an Horizontal Superficies (which may alſo tend to make us the more eaſily apprehend ſome of the following Terms and Expreſſions) we need only pour into a pretty large Glaſs, firſt ſome Water, and then ſome Oyl of Turpentine, for the Purpoſe; by which Means the Superficies of the Oyl, and the Separation of thoſe two Liquors, will ſhew the aforeſaid Horizontal Plane, and the like will be obvious in almoſt all other Liquids that are unmixable.

We ſhall not here inquire whether the Superficies of a Stagnating Liquor be not likewiſe part of the Convex Superficies of the Globe of the Earth; but it is ſure enough, that it may be ſuppos'd, without Miſtake, that it does not differ viſibly from a Horizontal Plane in ſo ſmall a Space as we are treating of.

IV. I add moreover, that we do not here pretend, with ſome Mathematicians, to demonſtrate every thing from Mechanical Principles; but only to ſhow Experimentally the Action of Preſſure or Gravitation of Fluids, as they are govern'd by the aforeſaid Laws of Preſſure according to their *Height* or *Depth*, that we may render them plain and intelligible to every body, and even to ſuch as are not converſant in Mathematicks.

SECT. XXII. *The Order of the Experiments that are to be made for the Foundation of Hydroſtatical Laws.*

TO proceed now, after premiſing theſe things, to the Law itſelf of the Preſſure according to Height, we can perhaps do nothing better in order to be more plainly underſtood, and to give a true Conception of our Meaning, even to the moſt Ignorant, than to ſet before the Reader a few eaſy and not coſtly Experiments; for which Purpoſe I ſhall relate them juſt as they ſtand upon my Notes, taken about 16 or 17 Years ago, and in the ſame Order too, namely, That the firſt Experiments are made by one only Liquor, not ſo much becauſe it is the uſual Manner in which Philoſophers treat theſe Hydroſtatical Subjects, nor becauſe Water, which is the Fluid commonly made uſe for theſe Purpoſes, has no other Fluid Matter over, or above it, ſince Air is always above, and preſſes upon it; but merely becauſe theſe Demonſtrations are more ſimple, and therefore more plain to Beginners, and that becauſe the Air gravitating with equal Force upon equal Parts of the Superficies of Water, this Liquor may be much more conveniently uſed and obſerv'd, than if any other Fluid Matter were incumbent on it.

The ſecond Sorts of Experiments do herein differ from the former, that they repreſent to us the Action of ſeveral Fluids upon one another.

SECT. XXIII. *Of Fluids in Curve Tubes of equa Bigneſs.*

BUT before we enter upon theſe Experiments we ſhall premiſe what, among other things, ha been firſt found to happen in Curve Tubes o an equal Bore.

To wit, That in order to cauſe a Fluid Matter in the Curve Tube A I D, (*Tab.* XXV. *Fig.* 1. to quieſce or ſtop at the Height A B in the Sid A I, and to hinder it from deſcending on accoun of its Gravity, you muſt fill the other Side I D with the ſame kind of Fluid, up to the lik Height. This is plain enough in itſelf, and th Experiment may be eaſily made.

SECT. XXIV. *An Experiment to ſhow the grea Force of the Gravitating Power of Water.*

THE firſt Experiment which was about th *Gravitation of Water*, was the following:

I. I put into a large Glaſs Veſſel A B C D (*Tab.* XXV. *Fig.* 2.) a Curve Tube Y X Q, anc a ſtreight one Z *t*, after tying them in ſuch a manner to a Piece of Wood that lay a-croſs o horizontally upon the Rim of the Glaſs, not onl as to make Right Angles, but likewiſe that thei loweſt Orifices, P Q and *r t*, which were of equa Bigneſs, were equally deep, that is, ſtood i the ſame Horizontal Plane L M.

Then pouring Water into the Veſſel as high a to *a b*, we might perceive the Water in both the Tubes to riſe up to *d e* and *n m*; and as fa as it appeared to us, it aſcended as high in the Tubes (which were choſen large for that Purpoſe as it did in the External Veſſel.

II. Now foraſmuch as the Water could not of itſelf riſe as high as *d e* in the Curve Tube Y X Q, nor remain ſuſpended there unleſs a Force preſs'd it down at P Q, as appeared, becauſe upon ſtopping the ſaid Tube with one's Finger at Y, and lifting it out of the Water in the Veſſel by the Piece of Wood E F, if we removed the Finger from Y, we ſaw that the Water did not only not remain at *d e*, but ſubſided to *u w*, driving out that which ſtood in its Way at the Orifice P Q.

III. From whence therefore it was obvious, that whilſt the Tube was in the Water, a Gravitating Power acted upon the Part P Q of the Horizontal Plane L M.

IV. Now to inquire into the Properties of this perpendicularly Gravitating Force:

It appear'd, *Firſt*, that the Force which preſs'd the Part P Q of the Horizontal Plane L M, did by no Means regulate itſelf according to the Surface or Breadth of the Water *ab*, nor yet to the Quantity of the whole Maſs of Water *a b* L M, which was incumbing upon the Horizontal Plane L M, of which P Q was a Part; of this we aſſured ourſelves by putting the Tube Y X Q as low as *d e*, in a much larger Veſſel; for inſtance, in a Bucket or Tub; in which Caſe we found, that notwithſtanding the greater Breadth when the ſame Depth of Water was incumbing upon P Q; yet the Preſſure upon the Part P Q was not greater, ſince it could not cauſe the Water in the Tube to riſe higher than to *d e*.

V. It appear'd, *Secondly*, that this Gravitating Force upon P Q, adapted itſelf moſt nicely and exactly to the Depth of the Water *a* L, which was the Column of Water incumbing upon P Q and L M.

For pouring gently ſome Water into the Veſſel, till it aſcended on the outſide of the Tube to A B, we likewiſe obſerved the Water within the Tube, to riſe from *d e* to R S.

But on the contrary, when by ſucking or letting out ſome of the Water out of the Veſſel, it was reduced to the Depth of *a b* or lower, the internal Water did alſo ſubſide to *d e* or yet lower, but ſo as always to continue of the ſame Height with the External.

VI. Now it has been ſhewn before, and it alſo follows from *Sect.* XXXIV. that if the Curve Tube Y X Q were extended from P Q to N O, or higher, and then fill'd up to the Height of *g h* or *a b* of the Veſſel, the Preſſure of this Column of Water P Q *h g* would be great enough to ſuſtain the Water in the other Shank of the Tube to *d e.*

VII. So that we may conclude from hence, that the whole Maſs of Water in the great Veſſel *a* L M *b*, gravitates as much, but neither more nor leſs, upon P Q, than this ſame Column of Water P Q *h g*.

VIII. Now ſince this Column P Q *h g*, is equal to a Column whoſe Baſis was the Part P Q of the Horizontal Plane L M, and whoſe Height is the perpendicular Height P *g* or Q *h* (or otherwiſe L *a* or M *b)* or the Water incumbing from *a b* upon the Horizontal Plane L M: A famous Propoſition in Hydroſtaticks is deducible from hence, namely, That if we ſuppoſe a Horizontal Plane paſſing thro' a ſtagnating or quieſcent Fluid, the Force whereby a Part thereof, as P Q, is gravitated upon, or preſs'd down, is equal to the Weight of the aforeſaid Column P Q *g h*, whoſe Baſis is the Area of P Q Part of the Horizontal Plane L M, and the Height of which is *a* L, or M *b*, or the whole Height of the Fluid imcumbent upon the ſaid Horizontal Plane, meaſuring the ſame directly upwards.

IX. This Column (becauſe it extends itſelf from the ſuppos'd Horizontal Plane to the uppermoſt Superficies of this ſingle Fluid, and, if there be more Fluids imcumbent on each other, to the uppermoſt Superficies of that Fluid which is higheſt, and contains all the perpendicular Heights of all the Fluid Matters impreſſing or incumbing on each other) we ſhall hereafter, for Brevity ſake, call the Column of *Altitude*.

X. Now to ſhew that there happens not only to this one, but to all equal Parts, as P Q, of the ſame Horizontal Plane L M, one and the ſame Preſſure, and each equal to the Weight of this Column, we remov'd the little Piece of Wood E T, with the Curve Tube Y X Q that was tied to it, from one Part of the Veſſel to the other, ſo that the Orifice P Q fill'd at every Turn a new Place of the ſaid Horizontal Plane, but we always found the Water ſtopping at *d e*, or at the ſame Height; and conſequently that every Part equal to the Area P Q of a Horizontal Plane L M, is always preſs'd down with an equal Force, which is alſo equal to that of the Column of Height.

XI. And to ſhew farther, that the different Figures of Veſſels did not alter the Caſe, or that it is not neceſſary that this gravitating Column P Q *h g*, ſhould be always directly perpendicular to the Part P Q that it preſſes, we thruſt a

Piece of Wood I K, G H, with a flat Bottom G H, or a Beer-Glaſs, or a Phial with the Bottom downwards, to a certain Depth as G H, under the Superficies of the Water *a b*, and held it there immoveable; after which we turn'd the Tube Y X Q quite about, bringing the Orifice P Q to *p q* directly under the aforeſaid Bottom, and we obſerv'd, that notwithſtanding the gravitating perpendicular Column over *p q*, could not extend itſelf higher than to G H, yet the Water remain'd in the Tube at *d e*, and conſequently at the ſame Height, as if the whole Column of Altitude P Q *h g*, were ſupported or reſted on P Q.

XII. So that it appear'd from thence, that each Part P Q, *p q*, &c. of the Horizontal Plane L M, was not always juſt preſs'd by the Column of Altitude itſelf, but by a Weight equal to that of the ſaid Column; and conſequently that this Law obtains in Veſſels of all Figures, of which, tho' there be here but one ſingle Inſtance given, and numberleſs Veſſels might be propos'd for Tryal, ſufficiently confirms our Poſition with the Concurrence of all that are vers'd in *Hydroſtaticks*, and abundance of Experiments in all kinds of Veſſels.

XIII. I muſt however endeavour to remove one Difficulty, which it may be renders what we have juſt now ſaid obſcure to ſome People, and then paſs on to ſomewhat elſe.

It is this, If a Drinking-Glaſs or Cup *k l* 7, 8, be filled with Water, and then inverted ſuddenly, ſo that the Mouth 7, 8, deſcends below the Superficies *a b*; and if one continue the Cup or Glaſs in the ſaid Poſture, it will be found:

Firſt, That the Water will deſcend either to *k* L or *c f*, according as there was more or leſs of it in the Glaſs, but by no Means ſo low as 9 or 10, or as the external Water *a b*.

Secondly, That in caſe the Curve Tube Y X Q, in which the Water is at the Height of *d e*, be turn'd about in its String and ſhov'd forwards, if neceſſary, with the Piece of Wood E F, ſo that the ſaid Tube Y X Q be brought to 1 4 6 and its Orifice P Q to 5 6 directly under the Glaſs *k l* 7 8 (continuing ſtill in the Horizontal Plane L M) we ſhall find that the Water will remain in the ſaid Tube immoveably at 2 3, the ſame Height as *d e*, and as the external Water *a b*.

Now ſince each part P Q and 5 6 of the Horizontal Plane L M is preſs'd by the Column, the Height of which is equal to the Height of the Water, and foraſmuch as there is no more Weight upon P Q than the Column P Q *g h*, and ſince there ſeems to be incumbing on 5 6 a Gravitating Column 5 6, *f c*, of a greater Depth, and conſequently of a greater Weight than that of P Q *h g*; it ſeems that it ought to follow likewiſe, that the Preſſure upon 5 6 ſhould be much greater than that upon P Q; and therefore that the Water in the Tube at 1 4 6 ſhould aſcend much higher than 2 3 or *d e*, but on the contrary, the Water at 2 3 or *d e* continues at an equal Height with the external *a b*.

This Experiment would be a notable Objection againſt what we have advanced, were it not that all who are any ways vers'd in *Hydroſtatics*, know, that what is ſaid before, is only meant when there is no other gravitating Fluid upon the Water *a b*; and that the Preſſure of the Air, which always gravitates upon the Water *a b*, is only the Cauſe here that the Water continues ſuſpended in the Glaſs or Cup at *c f*. That in caſe no Air preſs'd upon the Water *a b*, the Water in the ſaid Glaſs *k l* 8 7 would not continue higher than the external Water *a b* or 9 10, tho' the Glaſs be inverted ; as is well known to thoſe that uſe Air-Pumps.

So that this Objection is properly of no weight againſt what we have aſſerted, ſince we only treat of Caſes in which the Preſſure of the Air produces no remarkable Alterations, or at leaſt, in which we may ſuppoſe them.

SECT. XXV. *Experiments proving that Fluids preſs upwards.*

XIV. To proceed now to the Preſſure of Fluids upwards:

That in Water and other Fluids a Preſſure upwards has likewiſe Place, may be inferr'd from many Water-Works and Fountains that throw up Water.

This will alſo appear by the ſtrait Tube Z *r t*: For unleſs the Water at the Part *r t* of the Horizontal Plane L M were preſs'd upwards, it would not be poſſible that the Column *r t n m*, which lies upon the Superficies of the External Water *a b* in the Veſſel, could keep its Station at *n m*, ſince it is continually preſs'd downwards by its own Weight.

To give then an Inſtance thereof: Stop the empty Tube Z *r t* with your Finger at Z, and thruſt or put it down into the Water as far as *r t*, you will thereupon find that the ſaid Tube will remain empty from Z to *r t* or thereabouts ; excepting perhaps, that by the Preſſure upwards of *r t*, the Water may riſe a little, or ſo much higher in the Tube than *r t* (if let down into a great Depth where the Preſſure upwards is ſtronger) as the Force of the ſaid Preſſure can contract or ſqueeze together the Air which is in the Tube.

But in order to know with what Force *r t* is preſſed upwards, you need only remove your Finger away from *z* the Orifice of the Tube, and ſo give a free Paſſage to the internal Air which is driven againſt the Finger by the preſſure of the Water from below, and you will find (in caſe the external Water be as high as *a b*, and the Tube be tolerably large, ſo that there be not too great an adherence of the Particles of the Water to the ſides of the Tube, on account of its narrowneſs) I ſay, you will find that the internal Water will not only riſe as high as the external Surface *a b* or *n m*, but much higher at firſt, for Inſtance, up to T V; and that it will afterwards fall down from thence below *n m*, and not till after ſome Vibrations up and down, continue at *n m*.

From which Motion, or Aſcent and Deſcent of the Water in the Tube Z *r t*, it is plain that it is not only hinder'd by a Reſiſtance from falling down, as if it were oppos'd by a ſolid Body at *r t*; but that a real and actual Power obtains here, and operates like Weights in the Scales of a Balance, which do likewiſe fluctuate or dance up and down, before they arrive at a juſt Equilibrium.

Finally, this Force preſſing upwards, ſeems to be fully proved by the following Experiments.

Take a crooked Tin Tube (*Tab.* XXVI. *Fig.* 1.) A D F, which is of ſuch width at E F, as to be exactly cover'd with the Top or Lid of a little wooden Box E G H F. Put it down into a Veſſel N T C O fill'd with Water up to the Surface N O, and you ſhall find that the little Lid * E G H F, tho' much lighter than the Water, will

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* N. B. *The beſt Way to make this Experiment, is to keep the Lid down with your Finger cloſe to the turn'd-up end of the Tube* E F, *till it be about an Inch or two under Water.*

will ſubſide like a Stone, and how deep ſoever it be placed in the Water, will remain immovable on the Orifice E F of the ſaid Tube, until the Water inſinuating itſelf between the Lid and the Tube, raiſes it ſelf upwards, or till filling the Tube to 1, 2, 3, 4, the Air at 3, 4 E F, raiſes up the ſaid Lid.

Hence it is plain, that if a lighter Body than Water (for Inſtance, ſo thin a Subſtance as this little piece of Wood) is not rais'd by a real *Force preſſing upwards*, that it will by no means float, but ſubſide like heavier Bodies. We ſhall ſhow hereafter, that Water can even raiſe and cauſe Lead to float by the like Force; but what we have advanced, is ſufficiently confirm'd by the preſent Experiments.

SECT. XXVI. *An Experiment to ſhew the Greatneſs of this upward-preſſing Force.*

XV. FROM this Water ſuſpended in the Tube Z *r t* (*Tab.* XXV. *Fig.* 2.) we may judge *Firſt* of the Greatneſs of the upward-preſſing Force, at *r t* for Inſtance; for ſince there is one Force acting by an upward Preſſure, and another by a downward Preſſure upon *r t*, as has been prov'd before, it is plain, if the Fluid at *r t* does neither aſcend nor deſcend, but remains at the ſame Point, thoſe two Forces or Powers muſt be equal to each other; for if either prevail'd, the Water at *r t* would be moved according to the Direction of that Power.

Now ſince *r t* is preſt downwards by the Column of Altitude *n m r t*, as is ſhewn before; it is plain that *r t* is alſo preſt upwards by a Force equal to the Weight of this Column of Altitude.

This may be proved by a ſtill different Manner.

Take a Tube, which for Convenience ſake ſhould not be too large, and thruſt it down into the Water as far as 11, 12, *r t*: Stop the Mouth of it with your Finger at Z; then if you lift it up perpendicularly out of the Water, the inclos'd Fluid will remain ſuſpended at 11, 12, *r t*, as is known to thoſe who try Wines; then put the ſaid Tube again into the Veſſel fill'd with Water up to *a b*, ſo as the internal Water 11, 12, may be below the Surface of the external *a b* or *n m*, or elſe above the ſame.

If then you remove your Finger from Z, you will ſee in the firſt place, that the Force which preſſes *r t* upwards, is greater than the Weight of the Column *r t* 11, 12; and that it will cauſe the Fluid to riſe from 11, 12 to *n m*, or to an Height equal to the external Water *a b*.

On the contrary, if you take away your Finger from Z, when the Fluid 11 12 *r t* is up at T V or higher than the Water *a b*, you will find that Upward-preſſing Force at *r t*, is leſs than that of the Column of Water *r t* T V, and conſequently that the ſaid Column will deſcend notwithſtanding the Force which preſſes upwards, as low as *n m*, or *a b*.

Only if you thruſt down the Tube with the included Water ſuſpended for the Purpoſe at *n m*, till the ſaid *n m* be parallel with the horizontal Plane *a b*, or till the internal Water *n m* be of an equal Height with the external *a b*; you will ſee, that upon removing your Finger, the Water in *r t m n*, will remain there without riſing or falling.

From whence it may be inferr'd, that the Forces which preſt upwards and downwards, are in this Caſe equal to each other; and therefore that a

Part *r t* of the Horizontal Plane, as it is preſt downwards with the Weight of the Column of Altitude *r t n m*, is likewiſe preſt upwards in Stagnating Fluids, with a Force equal to the Weight of the ſaid Column.

XVI. If now, upon removing the Tube Z *r t* faſten'd to the little Piece of Wood E F, and carrying it along all the Parts of the Horizontal Plane L M, the Water remains continually Suſpended in the Tube at *n m*; it follows, that every Part of the ſaid Plane equal to the Orifice *r t*, is preſt upwards with an equal Force.

XVII. Now that this Upward-preſſing Force adapts itſelf exactly to the Depth, but by no means to the Breadth, nor to the Quantity of the Water ſtanding above a Horizontal Plane, may be ſhown here, as it was before, by the Force that preſſes downwards. For if you pour Water into the Veſſel till it aſcends from *a b* to A B, the upward Preſſure will be proportionably greater at *r t*, and cauſe the Fluid in the Tube to riſe from *n m* to T V.

But if afterwards you draw off ſo much of the Water in the great Veſſel, as to bring it down from A B to *a b*, or lower, the upward preſſing Force will proportionably leſſen; and whereas it was able before to raiſe the Internal Fluids as high as T V, it can't now keep it up beyond *n m*.

Thus we ſee every Thing adapts itſelf to the Heighth or Depth.

And if you have a mind to make this Experiment with a Bucket or Tub of Water, or with any other Veſſel greater or ſmaller than that we uſed, you will find that the Breadth or Surface of the Water makes no Alteration, nor will the upward preſſing Force produce any greater or leſſer

Effect, than to continue the Fluid *n m* in the Tube ſuſpended at the Height *a b* of the external Water.

Sect. XXVII. *The Laws of Preſſure up and downwards.*

XVIII. From all this it is eaſie to conclude, with Reſpect to the upward and downward Preſſure compared together, that,

If we ſuppoſe a ſtagnating Fluid (*Tab.* XXV. *Fig.* 2.) a Horizontal Plane from L to M, a Number of equal Parts taken at Pleaſure, ſuch as P Q, *r t*, *p q*, *n m*, 56, *&c.* each of theſe Parts.

Being *Firſt* preſs'd upwards with an equal Force:

And *Secondly*, downwards, with one and the ſame Force as another, be it what it will.

Thirdly, (and which is of great Uſe in *Hydroſtatics*) that one Part, as P Q, taken at Pleaſure, is preſs'd with as much Force downwards, as another that is equal to it, as *p q*, *r t*, *&c.* likewiſe taken at Pleaſure, is preſs'd upwards.

And alſo on the contrary;

That the firſt Part P Q, is preſs'd with as great a Force upwards, as *p q*, or *r t* are preſs'd downwards.

Fourthly, That the Force which preſſes each Part upon the other, is equal to the Weight of the perpendicular Column of the Fluid.

All which is plain enough from the foregoing.

Sect. XXVIII. *An Experiment of the Downward Preſſure of different Fluids upon one another.*

XIX. Hitherto, like many others, who write about *Hydroſtatics*, we have only conſider'd

Water as a Fluid that has no other upon or over it. But foraſmuch as there is another fluid Matter which is uſually incumbent on it, namely the Air, and which in ſome Caſes does often and notably exert its Power, as we have ſhown above, *Sect.* XIII; it will not perhaps be diſpleaſing to ſuch as have not been much converſant in *Hydroſtatics*, if we ſhould here conſider ſome of the Properties of different Fluids lying upon each other.

The *Experiment* therefore which we made ſome Years ago for this Purpoſe, may be perform'd with all unmixable Liquors; as theſe two are in which we ſee Brandy that has ſtood a while upon Pot-Aſhes, to which we may joyn Oil of *Turpentine* for a third unmixable Fluid. We only try'd the ſame with two, to wit, with Pickle or Water, in which there was as much common Salt diſſolv'd as could be, and with Oil of *Turpentine.*

We therefore took two little Sticks *c d*, and *e f*, and bound them to a Piece of Wood *g h* (*Tab.* XXV. *Fig.* 3.) which, as in the foregoing Experiment, we placed upon the Horizontal Rim of a pretty large and deep Glaſs-Veſſel, ſo that the ſaid Sticks made right Angles with the Piece of Wood, and deſcended Perpendicularly into the Veſſel; to one of 'em we ty'd the Curve Tube C G B, to the other the Streight one D E F, in ſuch manner, that the upper Orifice of each, C and D, was a good way below the Rim of the Glaſs-Veſſel, and the lower Orifices A B, and E F (which as the Tubes themſelves were of about the ſame Size) were placed as near as poſſible in the ſame Horizontal Plane H E.

XX. Now to give a rough Notion of the Preſſure of the Air; we pour'd ſome Pickle into the Veſſel up to H I, which running into the Tube B G C, at the Orifice A B, aſcended in the oppoſite Leg up to the Height *k l*, being Parallel to the external Liquor H I, and there it ſtaid.

When we remov'd the Tube, as in the former Caſe, from one part of the Superficies of the Pickle H I, we always found that the Liquor within the Glaſs remain'd unchangeably at *k l*.

From whence it appear'd, in caſe the Air gravitates, which we ſuppoſe here, that it preſſes upon equal Parts, ſuch as A B, *a b*, &c. of the Surface of the Pickle with equal Force: Since otherwiſe, if the ſaid Preſſure were greater on ſome Parts, and leſs on others, the Fluid *k l* in the Tube, would have riſen or fallen; if otherwiſe (which follows from what has been ſhown already) the Air in the Tube C G incumbent upon *k l*, and higher, does continually preſs upon the ſaid *k l* with equal Force. But this by the way.

XXI. HAVING pour'd in more Pickle, up as high as L M, we found the Liquor in the Tubes to riſe to *x y* and *z* 4; or as in the firſt Experiment, to the ſame Height as the external Liquor.

But when we pour'd upon the ſaid Pickle L M, Oil of *Turpentine* to the Height N O, the Liquor in the Tubes roſe from *x y* to *n o*, and from *z* 4 to *p q*; but remain'd below O N, or the Superficies of the Oil.

From whence we may infer, that a lighter Fluid, like the ſaid Oil N O L M, being incumbent upon a heavier, as the Pickle, produces both an upward and downward Preſſure: Since A B muſt be preſt more downwards to make the Pickle riſe from *x y* to *n o*; and E F with a greater Force upwards, to raiſe the Pickle from *z* 4 to *p q*, and keep it there ſuſpended.

XXII. AFTER

XXII. After this we thruſt down a Craner or Syphon with a long narrow Tube thro' the Oil N O L M, till it came below L M, or till it reach'd the Pickle; of which as we drew ſome part out, we obſerv'd, that the Depth of the ſame Fluid in both the Tubes decreas'd proportionably, falling below *n o* and *p q*, but roſe again as more Pickle was put in.

The ſame Thing happen'd upon taking out, and letting in again any part of the Oil N O.

And ſo did the laſt, with lifting upwards the Orifices of the Tubes A B, and E F.

From whence it appears, that in ſeveral Fluids incumbent upon each other, as well as in one alone, the Preſſures which raiſe and fall the Parts of any Horizontal Plane in each of the Fluids, are likewiſe adapted to the Depths of the incumbent Fluids.

But they are no ways affected by the Breadth of Fluids, ſince it is ſufficiently known to all that underſtand *Hydroſtatics*, that in caſe the Height of the Fluids over A B and E F continues the ſame, the Effect would be the ſame; and the Pickle at *n o*, and *p q*, would continue at the ſame Height in Veſſels of all kinds of breadths.

XXIII. We likewiſe found, that if we carry'd the Orifices of theſe Tubes A B and E F laterally along the Parts of the Horizontal Plane of the Pickle H I (the ſame may be ſaid of the Oil too) the Liquor in the Tubes preſerv'd the ſame Depth or Height in every new Place upon the ſame Horizontal Plane, as was obſerv'd in the firſt.

From whence it may be concluded, as before, that all equal Parts of a Horizontal Plane, whether the ſaid Plane runs thro' the uppermoſt Fluid, or thro' any other which has more Fluids incumbent on it, are preſt upwards and downwards with equal Force.

SECT. XXIX. *Oil gravitates or preſſes on Pickle, in the ſame manner as Air does on Water.*

XXIV. TO repreſent now in a ſhort Sketch, how Air operates upon a Fluid below it; we need only pour in Oil till it riſes up to P Q, or above the upper Orifices of the Tubes C and D; which by that means running into the ſaid Tubes, it will cauſe the Pickle within them to ſubſide from *n o* and *p q*, to *x y* and *z* 4, or to an equal Depth with the external Pickle at L M, juſt as if the Air preſt upon it.

SECT. XXX. *The Greatneſs of the Preſſure Upwards and Downwards in ſeveral Fluids incumbent upon one another.*

XXV. *Laſtly*, LET us again ſuppoſe N O to be the upper Superficies of the Oyl. Now to ſhow with how much Force every equal Part of a Horizontal Plane H I, ſuch as A B, E F, *&c.* are preſt upwards and downwards, when there are ſeveral Fluids incumbent on each other; we pour'd Quickſilver into the Curve Tube A B G C, till it roſe to an equal Height in both Legs, namely, to A B, and *k l*. Then we pour'd into the great Veſſel, Pickle as high as L M, and Oyl of *Turpentine* as high as N O, and ſo thruſt down the Tube B G C thro' the Oyl into the Pickle, as far as H I; and when all was quiet and ſettled, we found that the Quickſilver had ſubſided in one Shank from A B to T U, and riſen in the other from *k l* to *r s*.

This remaining ſo, we filled another Curve Tube of equal Legs (*Tab.* XXV. *Fig.* 4) 7 8 9, firſt,

firſt below to a certain Height (as here alſo A B and *k l*) with Quickſilver, and bringing forwards the Curve Tube C G B, *Fig.* 3. cloſe to the ſide of the great Veſſel; we meaſured with Compaſſes as nicely as we could, the Height of the Pickle U W above the Quickſilver T U.

We alſo pour'd Pickle into the other equal Leg'd Tube 7 8 9, *Fig.* 4. till it roſe to the ſame Height as W U above the Quickſilver that was in it, equal to the Pickle in the Veſſel. After which, meaſuring in the like manner the Oyl in the Veſſel at M O; we alſo pour'd Oyl into the Equicrural Tube to the ſame Height W X; ſo that the Pickle and the Oyl, as well in the ſaid Tube, as in the Veſſel, were both ſuſpended at an equal Height above the Superficies of the Quickſilver T U.

I ſhould add here, that in order to bring Pickle and Oyl into the Equicrural Tube *Fig.* 4, with thoſe in the Veſſel, you muſt take care you do not pour them in at firſt to the Height required; becauſe the Tube not being very large, when that which ſticks to the Sides at pouring in comes to ſubſide, it will cauſe it to riſe higher than in the Veſſel. This may be obviated perhaps by firſt filling the Tube *Fig.* 4, and then by pouring Pickle and Oyl into the Veſſel. They that have a mind may make the Tryal.

Afterwards having meaſured with Compaſſes the Height *r u* (which the Superficies of the Quickſilver *r s* in one Leg, had above the Superficies T U in the other) in both Tubes in and out of the Veſſel, we found the ſame Height *r u* to be equal in both.

XXVI. FROM whence we plainly perceiv'd, that all the Fluids incumbent on each other in the Veſſel above T U, and conſequently alſo above A B, did equally gravitate upon A B in the Veſſel; and neither more nor leſs, than if the ſaid Fluids had been in a narrow aſcending Tube, each in its ſtreight perpendicular Height.

For ſince the Tubes both within and without the Veſſel (*Tab.* XXV. *Fig.* 3 and 4.) were about the ſame Width; if the Side-Fluids in the broad Veſſel gravitated more upon A B, than the perpendicular Column A B Y X in the Equicrural Tube upon A B *Fig.* 4; it would follow that the upper Superficies of the Quickſilver *r s*, in the Veſſel, would riſe higher above the former Superficies *u w* of the ſaid Quickſilver than in the Equicrural Tube.

XXVII. The contrary of which being found to be true in all the Parts of a Horizontal Plane, (as H I) where-ever the Orifice of the Tube A B is placed, it ſhew'd, That when Fluids are incumbent upon each other in a Veſſel, ſuppoſing in one of 'em a Horizontal Plane, as H I, no Part thereof will ſuffer either more or leſs Preſſure from all the incumbent Fluids, how broad ſoever the Veſſel is, than of a Column A B X Y; the Baſis of which is A B, and the Top of it reaching up to the upper Superficies of the higheſt Fluid N O; and this is what we have call'd *the Column of Altitude.*

XXVIII. Now as we have deſcrib'd above the Column of Altitude in a Fluid, it may be concluded how the ſame is ſo plainly deſcrib'd in this Caſe; to wit, that in ſeveral Fluids incumbent upon each other, *the Column of Altitude* conſiſts of a Pillar, whoſe Baſis or Bottom is A B, or E F, for Inſtance, or ſome part of a ſuppoſed Horizontal Plane H I, and whoſe Top is the upper Surface of the uppermoſt of all the Fluids that are incumbent upon each other; as for Inſtance, B Z compos'd of the ſeveral Depths of the Pickle B W, of the Oyl W X, and of the Air X Z (imagining that X Z extends itſelf to the upper part of the Air) in ſuch manner, that each Height as B W, W X, and X Z preſſes downwards with the particular Weight of every Fluid of which it is the Height.

XXIX. It ſhould be obſerved here, that it is not neceſſary that each Part ſhould be always preſt with ſuch a perpendicular Column, ſince *a b* ſuffers the ſame Preſſure, notwithſtanding (if we ſuppoſe K to be a ſolid Body) that the Column directly incumbing upon *a b*, or *a b m i*, can't extend itſelf in a ſtreight Line higher than to *m i*, provided the Surface of the upper Fluid be at the ſame Height as before; but the meaning of all that has been ſaid is, that both *a b* and A B are preſs'd with a Weight which is equal to the *Column of Altitude*, *Num.* XXVII.

XXX. So that in order to inquire into the Nature of any Water-Works, with reſpect to the Preſſure of the Water upwards and downwards, you may ſingle out a part A B, *Fig.* 4. of a Horizontal Plane H I, upon or over which the whole Column of Altitude A B Z may be placed; or otherwiſe you may lengthen out the Horizontal Plane H I towards N or I, even beyond the Veſſel that contains the Part A B, (*Tab.* XXV. *Fig.* 3.) upon which we ſeek for the Preſſure, and moreover take an equal Part A B, (*Tab.* XXV. *Fig.* 4.) of the ſaid Plane extended from I to B, on which the Column of Altitude may be ſet and repreſented, if we continue the Superficies M L and N O, *&c.* of the Fluids incumbent on each other as far as W and X.

So that to know with what Weight *a b*, in the Veſſel, is preſt; it may be anſwer'd, with the Column of Altitude A B Z, which is repreſented in *Fig.* 4. out of the Veſſel; of which Column B W is the Pickle, W X the Oyl, and X Z 8 quite to the Top is Air.

We might alſo conceive the Column *a b m i* incumbent upon *a b*, as paſſing thro' a ſolid Body K, only by aſcribing to the Height of each Fluid Matter in it, its particular Part and Weight.

SECT. XXXI. *Of the Preſſure upon equal Parts of Higher or Lower Horizontal Planes.*

XXXI. IT is unneceſſary to add farther, that (*Tab.* XXVI. *Fig.* 2.) the Part *d* lying in the Horizontal Plane G T, is preſt with ſo much more Force upwards and downwards, than the Part *c* in a higher Plane E F, as the Column of Altitude *f m* upon G T, is heavier than the Column *f h* incumbent on the other Plane E F. This every one may apply to a Part *e* in a lower Plane N H, as alſo to ſeveral Fluids lying upon each other.

SECT. XXXII. *Hydroſtatical Laws of ſeveral* FLUIDS *incumbent on one another.*

XXXII. FROM all which then, there follows this great Hydroſtatical Propoſition (which does likewiſe very much contribute to diſcover the Powers and Motions in *Hydraulicks*, or Water-Works) after a ſhort and plain Manner.

It is thus:

If ſeveral Fluids be incumbent upon each other, and we ſuppoſe one Horizontal Plane, as H I (*Tab.* XXV. *Fig.* 3.) paſſing thro' one of 'em:

Two or more equal Parts thereof (as A B, *a b*, E F, *&c*) will each of 'em be preſs'd upwards and downwards, with the Weight of their Columns of Altitude, and conſequently with equal Force.

From whence it follows,

That one of theſe Parts, ſuch as A B, is preſs'd downwards with the ſame Force as another *a b*, or E F, upwards.

And on the contrary:

That the firſt A B is preſs'd with as great Force upwards, as another *a b*, or E F downwards; which we ſhall therefore, for Brevity ſake, call here the *Law of Altitude or Depth*, becauſe it adapts itſelf only to the Height (or Depth) of Fluids, but by no Means to their Breadth or Surface.

XXXIII. It muſt be here obſerv'd, that in the upward and downward Preſſure on equal Parts of the ſame Horizontal Plane (we do not now ſpeak of higher or lower Planes) it is meant of ſuch Parts A B, *a b*, E F, *&c.* which have a Communication with each other in the ſame Fluid; that is, ſuch as from one of which there may be ſuppoſed a Thread or Line drawn to the other, without being obliged to paſs thro' another Fluid, or Solid Body.

It is neceſſary to lay down this Caution here, becauſe this ſo general Propoſition may otherwiſe not ſucceed in ſome Caſes.

Sect. XXXIII. *The Preſſure upwards proceeds only from Lateral Fluids.*

We have no occaſion to prove expreſly, that all Parts, as *r t*, (*Tab.* XXV. *Fig.* 2.) of a Horizontal Plane L M, are preſs'd downwards by their own Weight, and that of other incumbent Fluids; but that they are never preſs'd upwards, but by Fluids that are not only higher but alſo lateral; and other parts of the ſame Horizontal Plane L M preſs downwards: So that all upward Preſſure proceeds from theſe Lateral Fluids, as from their neareſt Cauſes.

For take away the Lateral Fluids that are in the Veſſel *a* L M *b*, on the Outſide of the Tube *r t* T V, the Liquor in the ſaid Tube, loſing its preſſure upwards, will immediately ſubſide.

SECT. XXXIV. *Oblique Preſſures do likewiſe adapt themſelves to the Height of Fluids.*

XXXV. NOW to ſay ſomething concerning the *Oblique Preſſures* of Fluids.

That Fluids may be preſs'd and protruded in various Obliquities, is ſo plainly proved by the Cocks and *Ajutages* of many Fountains, as not to require any farther Demonſtration here.

But that theſe Oblique-preſſing Fluids do alſo adapt themſelves to the direct perpendicular Height of the ſaid Fluids over the preſs'd Part, as the foregoing, and by no Means according to their Quantity or Obliquity, ſhall be likewiſe briefly ſhown.

Take a Recurve Tube (*Tab.* XXVI. *Fig.* 3. and 4.) A B C D, which being continued from C D, aſſumes the Form of C E F N D; pour Water into it up to A, whereupon you will find that the Water will ſpread itſelf till it attains to an equal Height in the other Leg E F, of whatſoever Oblique Shape the ſaid Leg C D E F be, with reſpect to the preſs'd Part C D.

Now we know, that if the Tube were extended from C D, ſtreight up to C G H D, and and were full of Water as high as G H, or at a Height equal to A L and E F, the perpendicular Column C G H D, would keep the Water in the Tube A B, to the ſame Height A B, juſt after the ſame Manner as here in the Oblique Preſſure E F N D.

Conſequently the Horizontal preſs'd Part C D, undergoes an equal Preſſure from the ſtreight Colum C G D H, as from the Curve or oblique one C D F N D.

And this would be juſt the ſame, and remain ſo, though the Curve Tube (*Tab.* XXVI. *Fig.* 4.) were widen'd as at C E F K D, or even narrow'd in any other manner, ſo as to contain a greater or leſſer quantity of Liquor; as likewiſe in which Obliquity, one of the ſaid Tubes ſtood upon the Plane B C D, and preſs'd the Part C D; if only the preſs'd Horizontal Part C D preſerv'd the ſame Magnitude, and the Perpendicular Height G C, H D, or F M of the Fluids upon the Plane C D continued the ſame.

SECT. XXXV. *The Hydroſtatical Laws of Oblique Preſſures*

XXXVI. So that the foremention'd Law of Altitude, is here alſo of full Force in the Caſe of Oblique Preſſures; and the following Propoſition is true:

If a Part C D of a Horizontal Plane B C D, is preſs'd by a Curve or Oblique Column of Water C E F N D; the Preſſure it undergoes is neither greater nor leſſer, than that of the Column of Altitude; that is, of the Perpendicular Column C G H D, which has for its Baſis the preſs'd part C D, and for its Height the ſtreight Perpendicular Lines F M, or G C, which are extended from the preſs'd Part C D, to the uppermoſt Superficies A F of the higheſt Fluid, ſuppoſing there to be more than one.

SECT. XXXVI. *Lateral Preſſures do likewiſe adapt themſelves to the Heights or Depths of Fluids.*

XXXVII. IT now remains to inquire into the Force of the *Lateral Preſſure of Fluids*, whereby they are thruſt or preſs'd along the Horizontal Line.

That this kind of Preſſure does alſo obtain in Fluids, appears from the fitting or placing Cocks in the Sides of Barrels, *&c.*

Or otherwiſe, fix a Tube E F (*Tab.* XXVI. *Fig.* 5.) horizontally, or into the Side of a Veſſel A B C D, fill'd with Water to the height M N, and you will ſee the Water guſhing out in a Stream F G H; ſo that at E F it runs horizontally, and at F G H inclines or bends itſelf to the Earth.

And in order to know that this Lateral Preſſure does alſo adapt itſelf to the Height, you need only fill the Veſſel up to A B, ſo that there will then be a greater Depth of Water E B above the Tube E F; and you will find that the Stream F I K guſhes out ſo much farther, and horizontally to K; but that in Proportion to the Decreaſe of the aforeſaid Height, by letting out the Water, the horizontal Force does alſo decreaſe, and continually incline nearer to the Veſſel, as firſt at H and then at P.

Now that this Lateral Preſſure does by no means adapt itſelf to the Breadth or Quantity of the Water, may be ſeen, if by continually pouring Water into the narrower and wider Veſſel, ſuch as A B C D (provided it be not too narrow) the Water be kept at the ſame height A B; for then in both Caſes the Stream F I K will preſerve the ſame Horizontal Line.

SECT. XXXVII. *The Method of diſcovering the Greatneſs of the aforeſaid Preſſure.*

XXXVIII. BUT now in order to compare the true Force of the Lateral Preſſures, with that of the Heighth or Depth of Fluids upon equal Horizontal Planes, as we have done in other Preſſures, we muſt beſtow ſomewhat more Pains.

For if we take a quadrangular Veſſel (*Tab.* XXVI. *Fig.* 6.) A Q P K with plane perpendicalar Sides A Q, and P K; and in it conceive the part A E of the Side A Q, againſt which the Water, wherewith it is fill'd up to A K, preſſes laterally, and if you moreover conceive another part E I in the Horizontal Plane O E, and equal to A E; it is clear that upon each Point F, G, H, I, there is an equal Depth of Water *a* F, *c* G, *e* H, *g* I, and conſequently that each of the ſaid Points is preſs'd downwards with an equal Force; but nevertheleſs, that each of thoſe Points B, C, D, E, in the perpendicular Part A E, ſuffers an unequal lateral Preſſure; becauſe, as we have ſhown before, the lateral Preſſure accommodates itſelf to the perpendicular Height of the Water, and ſo is greater or leſs accordingly; and each Point, as A, B, C, D, E, has a different Height of Water above it, or rather above the Horizontal Plane in which each Point lies.

Accordingly the Point A, or the Horizontal Plane A K, has no Height of Water above it.

The Point B, or the Plane B L, has the Height A B or *a b* over it.

The Point C, or the Plane C M, the Height A C, or *c d*.

The Point D, or the Plane D N, the Height A D, or *e f*.

The Point E, or the Plane E O, the Height A E, or *g i*.

So that from hence it is manifeſt, that in order to know how much greater or ſmaller Preſſure the Horizontal Plane E I undergoes from the Water that lies in equal Height upon all its Points, than the Perpendicular A E, which has different Heights of Water over all its Points; that by reaſon of the great Difference of the Height of Water lying over the higheſt and loweſt Points of the perpendicularly preſs'd Part A E; to avoid Miſtakes, we muſt *Firſt* inquire how much greater or ſmaller the lateral Preſſure (for Inſtance) upon one of the Points B or C, *&c.* is, than the Preſſure downwards on one of the Points *b* or *d*, *&c.* which have the ſame Height of Water over them.

And, *Secondly*, when this is known in each Height *a*, *b*, *c*, *d*, *e f*, *g*, *i*, that we compare the Sum of all theſe different lateral Preſſures upon all the Points or little Planes that make up E A, with the Preſſure downwards, which all the Points or equal Breadths compriz'd in E I, do bear together.

Thirdly, It is plain, that the ſmaller the Parts or Points are into which A E and E I are divided, the leſſer is the difference of the Heights or Depths of Water over the uppermoſt and undermoſt Points of the Part of A E, and conſequently theſe Diverſities of the Heights will produce the ſmaller Change in the Calculations, which, if theſe Parts were taken very large, might occaſion great Difference; whereas they may be now ſafely enough taken, if we conſider the Parts of A E, ſuch as A, B, C, *&c.* as very ſmall, and mere Points.

SECT. XXXVIII. *The Compariſon of the Lateral and Perpendicular Preſſure of the Air upon an equal Part ſhown by an Experiment.*

XXXIX. To ſhew the *Firſt* experimentally, to wit, that the lateral Preſſure which ſuch a little Part as B, having a Height of Water, as A B, above it, undergoes in the Perpendicular A E, is equal, or at leaſt does not ſenſibly differ from the Preſſure downward, which a Horizontal equal Part *b* that has an equal Height of Water *a b* over it, ſuffers from the incumbent Fluid, may appear from what follows, propos'd, if I miſtake not, firſt by Mr. *Mariotte*, but with another View.

Having try'd the ſame in the Year *1696*, and ſeveral times ſince, I find among others, the following Remarks, which every Body elſe may alſo make by the help of the little Glaſs Inſtrument invented by Dr. *Muſſchenbroek* for the ſame Purpoſe, with little Charge and Trouble.

We caus'd a little Hole *a b* to be drill'd or bored in the Plane Side V Q of a Bottle A B P Q (*Tab.* XXVII. *Fig.* 1.) and another ſomewhat bigger at the Bottom of the ſaid Bottle at P, which laſt might be ſtopt by putting ſomething into the Hole, and the Mouth A B was ſtopt with a Cork C D F G, thro' which the Glaſs Tube E W was thruſt, and the Joints were ſo well ſodder'd with *Emplaſtrum de Minio*, that no Air could paſs neither between the Tube and Cork, nor the Cork and the Mouth or Hole.

Then ſtopping the little Hole *a b*, and the Glaſs Tube E with the Finger, we pour'd Water into the Veſſel thro' the biggeſt Hole P with a Funnel that had a very ſlender Noſe, till it aſcended to the Height R T, or higher than the little Hole *a b*, which otherwiſe requires no Bounds.

Moreover having clos'd the Hole P with a Cork or a Plug, we thruſt a little Tube *a b g h* a-croſs in the Orifice *a b*, which Tube being ſhut, or hermetically ſeal'd at *g h*, had a Horizontal Orifice at *f g*, as that at *a b*.

Then ſetting the Veſſel up an end again, and ſtopping the Orifice *f g* with the Finger, we fill'd the Tube E W almoſt to the Top with Water. After which I removed my Finger from *f g*, whereupon the Water ſpouted out of the ſaid Orifice *f g*, and ſubſided in the Tube E W; but without producing any other Alteration or viſible Diminution in the Height of the Water R T in the Veſſel, than what might be juſtly aſcribed to the Contraction or Expanſion of the Air incumbent on the ſaid Water R T.

Finally, All being at Reſt, it appear'd, that as the Water in the Veſſel continued at R T, that in the Tube E W ſtopt at *d u*, at the ſame Height with *f g*, or with the Horizontal Plane *d g*, which paſſes thro' *d u* and *f g*.

Whereby we perceiv'd that the Column of Air *f g* K, by its perpendicular Preſſure upon the Water at *f g*, could keep the ſame ſuſpended at the Height of *d u* in the Tube E W, and ballance an equal Column of Air *d u* H, which incumbed upon *d u*, according to *Sect.* XLI, *&c.*

Now to compare the lateral Preſſure upon *a b*, with the perpendicular Preſſure *f g*, we took the little Tube *a b h g* out of the Hole *a b*, and found that every Thing continued in the ſame State, and that hardly any Water flow'd out of the ſaid Hole *a b*; the Water alſo in the Tube E W remaining at the ſame Height *d u*.

For if it had fallen in the ſaid Tube, but a Hairs Breath, down to *e w*, by reaſon of the Difference of the Air's Height at *a* and *b* (which however was not obſervable) the ſame by making the Hole *a b* ſmaller, would have dwindled to nothing.

XL. Suppoſing then that the Water in the Tube E W did continue at the ſame Height, whether the Air preſs'd downwards upon *f g*, or a-croſs and ſidewiſe, upon *a b*, without the little Tube *a b g h*, it was plain, that the Air preſs'd with much the ſame Force by its Weight directly downwards and laterally or ſidewiſe, when theſe preſs'd Parts *f g* and *a b* were taken ſo ſmall, that the Heights I *a* and I *b* differ ſo little.

SECT. XXXIX. *An Experimental Compariſon of of the aforeſaid Preſſures in Water upon an equal Part.*

XLI. But ſince the abovemention'd Experiment does only ſhew the Equality of theſe Preſſures in Air, to the end, that the ſame may be repreſented in ſome other Fluid, as Water for Inſtance, we placed the aforeſaid Bottle A B P Q, with and without the Tube *a b g h*, in a Veſſel of Water L M N O: So that the Water in the Veſſel was as high as L O above that in the Bottle, and we obſerv'd in both Caſes that the Water in the Tube E W, roſe and continued at *r z* an equal Height with that in the Veſſel L M, and conſequently higher than that in the Bottle RT. So that the Water in the Veſſel L M N O, whether preſſing perpendicularly upon *f g*, or laterally againſt *a b*, exerted an equal Force and Preſſure upon equal Parts, as *f g* and *a b*, when taken ſmall enough.

SECT.

SECT. XL. *The Greatneſs of a Lateral Preſſure upon a Plane.*

XLII. From whence it follows, that we may return again to our former Thread, and to *Tab.* XXVI. *Fig. 6.* and compute what a Force of Preſſure a perpendicular Part A E ſuffers laterally from the Water as high as A K in the Veſſel A Q P K, in compariſon of the Force which an equal Part E I, lying horizontally, undergoes from the incumbent Water A E *i g*; we muſt firſt ſuppoſe the preſs'd Parts or Planes A E and E I to conſiſt of other ſmaller Parts, or of very ſmall Points, A, B, C, D, E, F, G, H and I.

Secondly, That each of theſe Points or little Particles B, C, *&c.* does ſuſtain juſt as ſtrong an Action from the lateral Preſſure, as *b* and *d* from the Preſſure downwards of the viſible Heights *a b*, *c d*, &c. of their incumbent Water.

XLIII. Let us then for Conveniency ſuppoſe that A E alone does conſiſt of five equal Parts, A, B, C, D, E, and E I of five Parts alſo, E, F, G, H, I: Tho' we ſhould proceed more ſurely, if we ſuppoſed theſe Parts to be much ſmaller, and that A E as well as E I, did conſiſt of ſome Thouſands or Millions of the ſaid Parts; foraſmuch as then the Heights *a b*, *c d*, &c. of the higheſt and loweſt Ends of theſe Parts would hardly be different, as has been already mention'd above.

We have however taken ſuch a ſmall Number as 5 here, it being ſo repreſented in the Figure, and becauſe, whether the Number of the Parts be great or little, the Iſſue of the Calculation will be the ſame.

To come to it therefore; If it be ſuppoſed that the Height *a b* contains 1 Pound, that *c d* 2 Pounds *e f* 3 Pound, *g* I 4 Pounds, and ſo on, if more Parts be taken, it has been proved before, that there is an equal *Lateral* Preſſure upon the Point

	℔.
A, as *downwards* on *a*, and becauſe there is no Height or Column of Water incumbing on *a*, it bears	0
On B as on *b*, and by reaſon of the Height *a b*, the ſaid *b* bears	1
On C as on *d*, and becauſe of the Height *c*, it bears	2
On D as on *f*, and becauſe of the Height *d f*, it bears	3
On E as on I, and becauſe of the Height *g* I, it bears	4
So that the Weight which all the Points together bear, is	10 ℔.
Furthermore: Each of the Points E, F, G, H, I have incumbing on them a Height or Column of Water equal to *g* I, and conſequently each bears 4 *l.* which being multiply'd by 5, there being ſo many Parts ſuppos'd in A E, and E I, the whole E I bears	20 ℔.

SECT. XLI. *The Hydroſtatical Law of Lateral Preſſures.*

XLIV. FROM whence therefore reſults this Principle concerning the lateral Preſſure of Fluids, namely, that the lateral Preſſure upon A E being, in this Caſe, 10 ℔. is the half of 20 ℔. or of the Preſſure downwards, which the ſaid A E if it lay horizontally at E I, level with the loweſt Point E, wou'd ſuffer from its incumbent Water A E I *g*; ſo that in order to know, the Water being at the Height A K, how great is the Preſſure which A E bears, we muſt ſet off A E horizontally on E I, which bears the Preſſure downwards of its incumbing Water A E I *g*; and draw E I, which will take in the preſſing Fluid A E I A, or the half of A E I *g*.

XLV. It muſt not be thought that if the Number of Parts, of which A E or E I are compos'd, were much greater than 5, it would alter the Proportions; ſince, let the Number be never ſo great, all the Numbers from 0 forwards, being continually multiply'd with the Unit, do always make up the half of their greateſt Number ſo often taken, as (the 0 or Cypher being reckon'd among them) their Quantity amounts to.

This is plain to Mathematicians, and any body elſe may, for his Satisfaction, compute it with a greater Quantity.

SECT. XLII, and XLIII. *Two Experiments about Lateral Preſſures.*

XLVI. YOU may find what we have ſaid *Num.* XLIV, and XLV. demonſtrated after another manner by Monſieur *Stevin*, in his *Hydroſtatics*; but ſince we, in order to render our Concluſions more certain, are wont to deduce our Proofs from Experiments, we will here add the following Experiment, as we find it ſtanding upon our Notes ſome Years ago, omitting the whole Calculation for Brevity ſake.

We caus'd to be made a Quadrilateral Veſſel (*Tab.* XXVII. *Fig.* 2.) the Height of which M K was about 26 Inches, with a ſquare Hole that could be ſtopp'd with a Piece of Wood H D R S of the like Dimenſions, being of the Breadth of a Foot at R D, and of the ſame Length at H D, which Piece of Wood was adapted to the Hole after ſuch a manner with a Leather fix'd to its

Edges, as to prevent the Water from oozing out at the Joints.

This Veſſel being fill'd with Water up to B D, we knew that there was the Weight of a Foot of Water preſſing laterally upon the Piece of Wood H D R S, becauſe the Height of the Water was equal to D R, or to the Height of the uppermoſt Part of the ſaid Piece of Wood.

Having then examin'd into the Force of this lateral Preſſure of the Water by Means of a Ballance A E F, the Arms of which A E and E F were Rectangular at E, to which the Weight Y was ſuſpended, we found that this Wood being preſs'd inwards at E A by Y, could reſiſt a Weight of between 31 and 32 Pounds; but upon adding more it immediately burſt inwards.

So that the Rule mention'd in *Sect.* LII. was ſufficiently verified hereby, ſince a *Rynland* Foot of that Water was about twice as heavy.

It is to be obſerv'd, that the preſſing Part A of the Ballance A E F, muſt be placed exactly upon the Point of the Wood A, where the Centre is, or where the lateral Preſſure is ſtrongeſt.

In order to do ſo, Care was taken that by the Means of the croſs Piece of Wood V W, the Axis E of the Ballance might be thruſt up or down; and we found that when the Ballance preſs'd higher or lower than A, the flat Piece of Wood (the Water being at higheſt) yielded to a much ſmaller Weight or Preſſure; which ſhew'd that the true Point was at A.

XLVII. We then fill'd the Veſſel quite full of Water up to G K, ſo that the upper Part D R of the wooden Plane D R S H, which bears the leteral Preſſure, was not equal to the upper Superficies of the Water, but was below it the Length of K D, or of $\frac{2}{3}$ of a Foot, that is, 8 Inches.

Wherefore if what is ſaid before be true, and that H K were $1\frac{2}{3}$ of a Foot, or 20 Inches, we ſhould have ſeen the lateral Preſſure on H D R S reſiſt a greater Weight.

Having therefore rais'd the Axis a little higher, ſo that A, the End of the Ballance, being hereby apply'd to the Center of the Preſſure, was alſo higher, we found that by putting on the Weight Y of 77 Pounds, the wooden Plane immediately gave way, but that the lateral Preſſure held good againſt 73 or 74 Pounds.

This agreed pretty near with the foregoing Rule, as we found by computing after the following Manner:

Let *Tab.* XXVII. *Fig.* 2. be transferr'd to *Fig.*3. and that the Water is from H S to K Z. Then H K equal to $1\frac{2}{3}$, or $\frac{1}{3}$ of a Foot is equal to P H (if we ſuppoſe this ſame H K to be lying horizontally) and H S is a Foot: So that the whole Body of Water of this Breadth, Length and Depth $\frac{25}{9}$ of a Cubical Foot; and the half of it, which preſſes laterally upon K H Z S will, be $\frac{25}{18}$ of a Foot. If now we ſubſtract from thence the Water's lateral Preſſure upon K D R Z, to wit, $\frac{4}{18}$ of a Cubical Foot, it being the Half of $\frac{4}{9}$ a Foot of Water (which laſt expreſſes the Magnitude of a Body, the Length whereof R D is 1 Foot, the Breadth *m* D $\frac{2}{3}$, and the Height K D likewiſe $\frac{2}{3}$ of a Foot) there will remain the lateral Preſſure of $\frac{21}{18}$ or $\frac{7}{6}$ of a Foot, or otherwiſe $1\frac{1}{6}$ of a Cubical Foot of Water, that is (ſuppoſing ſuch a Foot of Water to be *63* Pounds, or ſomewhat more) of $73\frac{1}{2}$ Pounds againſt H D R S; which ſufficiently agrees with the Rule mention'd *Sect.* LII.

SECT.

SECT. XLIV. *The Lateral Preſſure adapts itſelf to the Height, and not to the Breadth of Water.*

XLVIII. WE likewiſe obſerv'd, upon placing a flat Board or Partition (*Tab.* XXVII. *Fig.* 2.) T *a b*, after ſuch a manner, that the Water, which before preſs'd upon D H R S, became divided, or had not above the half *a* K of its former Breadth K G, that the lateral Preſſure was not leſſen'd, whilſt the Water continued at its firſt Height K G.

So that from hence alſo it appear'd, that the Powers of the lateral Preſſure remain the ſame, whether the Breadth of the Water be increas'd or diminiſh'd; but that upon augmenting or leſſening the Height of Water, thoſe Powers are accordingly augmented or leſſen'd.

SECT. XLV. *The Lateral Preſſure of Water, with Air preſſing upon the ſame.*

XLIX. But foraſmuch as in theſe Experiments of Lateral Preſſures we have ſuppoſed Water to be the uppermoſt Fluid, ſo that, for inſtance, in the Veſſel A B C D (*Tab.* XXVII. *Fig.* 4.) we are to ſuppoſe there is no other Fluid Matter above the Superficies of the Water A C, the following Difficulty ſeem'd to ariſe, namely, that the lateral Preſſure of the ſaid Water A C upon A B would be much greater than it is found to be by theſe Experiments; becauſe the Air between A C and and ooo, *&c.* actually preſſing upon A B with the Weight of 30 Foot of Water (according to the Barometer) the lateral Preſſure againſt A B would appear to be conſiderably encreas'd.

But upon the whole Matter, we ſhall ſhow by the following Calculation, that the lateral Preſſure of Water in the Veſſel A B D C upon A B, is not ſo much increas'd by the Weight of the Air above A C, as that the Force which A B withſtands, or which ſhould preſs inwardly againſt C D (like the Weight in the foregoing Ballance, *Fig.* II.) could be ſenſibly augmented thereby.

Let the Veſſel A B D C (*Tab.* XXVII. *Fig.* 4.) be fill'd with Water up to A C; above which let us ſuppoſe a Column of incumbing Air as high as o o o R o o o; we know that the ſaid Air being alſo on the other Side of A B, at A, B, *i*, *n*, will preſs likewiſe againſt A B laterally from the Side of *n i*.

Now to find what Preſſure A B undergoes by the Water on the Side D C, and by the Air on the Side *n i*, and how much the firſt Preſſure exceeds the laſt:

Let us call the Weight of the Air gravitating upon each Point in the Plane *n* N, to wit, *n* O, *m* O, E O, *&c.* by the Name of *a.*

Let the Gravitation of the Water K F on the Point F be *b*, then L G is 2 *b*, and M H 3 *b*, *&c.*

Let the Air-Weight of *kf* on the Point *f* be *c*; then is L *g*, 2 *c*; *m b*, 3 *c*, &c.

Whereupon (according to the Calculation in *Sect.* LI. if we do here alſo ſuppoſe five Points of Preſſure) the Force of the ſuperior Air, and of the Water in A B C D, which preſs A B laterally towards *n i*, will be 5 *a* with 10 *b*. And on the contrary, the Force of the upper Air, and of that Air which is at *n i* B A, which preſs'd A B laterally back towards D C, will be 5 *a* with 10 *c*. So that theſe two Powers preſſing laterally againſt each other, being drawn by each other, the Force wherewith A B is preſs'd laterally towards *n i*, will be 10 *b* leſs 10 *c*.

Now without the ſuperior Air, the lateral Preſſure of the Water (according to *Sect.* LI and LII.) would be equal to 10 *b*; and *c* is equal to about $\frac{1}{1000}$ part of *b*, if we ſuppoſe Water to be 1000 times heavier than Air. So that the ſurrounding Air does only leſſen the lateral Preſſure of the Water $\frac{1}{1000}$ part; which in the foregoing Experiment can make no ſenſible Alteration, and conſequently the abovesaid Difficulty is obviated.

SECT. XLVI. *The Augmentation and Diminution of the reſiſting Force of Fluids produces Motion, and the Force thereof.*

L. HITHERTO we have conſidered the upward and downward Preſſures of Fluids which are quieſcent or ſtagnant, either by reaſon of Powers really acting upon and againſt each other, or elſe by the Reſiſtance and Obſtructions of Motion; we ſhould now naturally proceed to inquire into the Powers of thoſe Fluids that are in actual Motion; but foraſmuch as this would require a whole Book to account for it, and ſince what we propos'd to ſhew here concerning the *Law of Altitude or Depth*, may likewiſe be conceiv'd by the Preſſure of ſtagnating Fluids; we will not inlarge this Digreſſion, which to thoſe who underſtand Hydroſtatics, may ſeem already much too long.

We ſhall only obſerve further concerning the Powers preſſing upon each other, that if in *Tab.* XXVII. *Fig.* 5. the Tube *b k g* is equally fill'd with Water up to *a* and *f*, ſince *d* is preſs'd upwards by *a b*, and downwards by *f d*, the Part *d* will quieſce or ſtand ſtill, if the Powers *a b* and *d f* are equal; but if one of 'em be leſſen'd to *e d*, or the other increas'd to *h b*, *d* will be removed towards that Side where the Force is ſmalleſt, or in this caſe to *g*; and even with as much Force, as the Difference of both Power's is, that act on each Side upon *d*. This may be eaſily try'd, and wants no further Proof.

SECT. XLVII. *Fluids are moved by, or rather after taking away a Reſiſtance, and the Force thereof.*

LI. MOTION may likewiſe be produced, by removing a Reſiſtance which obſtructed Motion. For Inſtance, blow into a Tube at *g*, which is fill'd in both its Legs with Water up to *a* and *f*, till the Water ſubſides from *f* to *e*, and riſes from *a* to *h* on the other Side; then preſently ſtop the Orifice *g* with your Finger, whereupon all will ſtand ſtill, and your Finger will become the Impediment or Reſiſtance of Motion. This appears by removing your Finger, upon which the Motion will enſue.

Now by what has been ſaid it is obvious, that whilſt the Finger continues upon *g*, and the Fluid is ſtagnant, the Part *d* is preſs'd upwards by *h b*, and downwards by *d g*; and that the reſiſting Power or Finger is preſs'd upwards by the difference of the Powers *h b* and *d g*. So that this Reſiſtance or Finger being taken away, a Motion will be made towards the Side of the Reſiſtance; and even with that Force with which the Reſiſtance was preſs'd when the Fluids were quieſcent, unleſs upon removing the Reſiſtance, no other actual Force begins to operate.

SECT. XLVIII. *Tranſition to* Hydraulics, *or ſome few Hydroſtatical Examples.*

NOW that Fluids do ſo exactly obſerve theſe Laws; that *Firſt*, every thing which is deduced from thence by good and juſt Conſequences (all Circumſtances being rightly obſerv'd) is likewiſe experimentally verify'd in the ſame; and *Secondly*, that theſe Fluids, before they recede from *this Law of Altitude or Depth*, do moreover produce Effects which, to ſuch as are unexperienced in Hydroſtatics, appear to be ſo many Wonders, and of whoſe manner of Operating, even the greateſt Mathematicians acknowledge themſelves ignorant, or at leaſt uncertain, we will prove by ſome few Inſtances.

SECT. XLIX. *Calculation of the Force of a* Syphon.

LII. THE Firſt Inſtance, that we may begin with one that is ſimple, ſhall be the Operation of a *Syphon.*

A B C D is a Veſſel fill'd to the Brim with Water (*Tab.* XXVIII. *Fig.* 1.) in it there is placed a Curve Tube or Syphon E G H K, likewiſe full of Water, the Orifice whereof I K is for that purpoſe ſtopt with the Finger or otherwiſe.

If now you remove your Finger from I K, every Body knows experimentally, that the Water will run out from I K to Z, riſing up in the mean while in that Part of the Syphon E G which is ſhorteſt, and coming down in the longeſt H K, as long as the Water in the Veſſel continues higher than the Mouth of the ſhorteſt Leg E F.

Now to know from the foregoing Principles, the Force and Manner whereby, and whereon this Operation of the Syphon is brought about:

Stop the Syphon again with your Finger at I K, by which means the Water in that, and in the Veſſel will ſtagnate.

Suppoſe then W X to be the upper Place of the Air which preſſes here upon the Water, and produce the Horizontal Plane of the Water A D, thro' P Q to R S, whereof L M, N O, P Q and R S are equal Parts; thereupon according to the preceding Rules, the Part L M will be preſs'd with the Weight of the Column of Air incumbing on it.

Let us for brevity ſake call the Preſſure of Weight thereof upon L M, *a*, or if you pleaſe 100 Pounds more or leſs; eſpecially if People be not uſed to this way of Letters.

Accordingly we will expreſs the Weight of the Water-Column P Q I K by *b* or 10 Pounds, and that of the Air R S T V, being of the ſame Height, by *c* or 1 Pound.

Now ſince L M, N O, P Q, which are all equal Parts of the ſame Horizontal Plane A Q, and all Water, and to all which we may ſuppoſe, that a Line or Thread may be drawn, without paſſing thro' a ſolid Body, or any other Fluid beſides Water.

And ſince by the Action of the Syphon the Plane L M moves, or is preſs'd downwards, that of N O upwards, and that of P Q again downwards, if every Thing be reduced to Reſt by ſtopping the Orifice I K, the Powers whereby the ſaid Planes were preſs'd up and downwards will be equal, according the *Sect.* XLI, *&c.* and L M being preſs'd downwards by the Weight of the Air-Column L W M, that is, by *a*, or by 100 Pounds, N O will be preſs'd upwards, and P Q downwards by the ſame.

If now we joyn to the Weight of this Air-Column of *a* or 100 Pounds which preſſes P Q downwards, the Water-Column P Q I K of *b* or 10 Pounds, by which I K is likewiſe preſs'd downwards; the Force or Weight that preſſes I K will conſiſt of *a* joyn'd to *b*, or of 100 and 10 Pounds, to wit, of the Air and Water-Columns together. And ſo it is with this Force, that the Water gravitates downwards to Z.

If now the Horizontal Plane paſſing thro' I K be extended to V, and T V ſuppos'd equal to I K, then will T V be preſs'd downwards by the whole Air-Column T V X, that is by R S X of *a* or 100 Pounds (the ſame being equal to L M W) and by R S T V of *c* or 1 Pound, that is, of *a* and *c* or 100 and 1 Pounds together.

Now with juſt ſo much Force (according to *Sect.* XLIII.) is the Part I K, or rather the Air preſſing againſt I K, or the Finger (if we do not conſider the thickneſs thereof) preſs'd upwards.

So that we ſee here two Powers preſſing againſt each other on I K, or the Separation of the Water and Air, operating and acting againſt one another.

Of which, that that preſſes I K downwards, has been found already to conſiſt of *a* added to *b*, or 100 and 10 Pounds. And that which preſſes I K upwards, to be no more than of *a* and *c*, or 100 and 1 Pounds; ſo that this laſt, *a* and *c*, or 101 Pounds, (*i. e.* the ſmalleſt Sum) being Subtracted from *a* and *b*, or 110 Pounds, the Remainder is *b* leſs *c*, or 10 leſs 1, that is 9 Pounds.

And this ſhows the Force wherewith I K is preſs'd downwards more than upwards, and it is equal to the Weight by which the Water-Column R Q K I, *b* or 10, exceeds the Air-Column P S T V, *c* or 1.

So that if you remove your Finger from I K, and ſuffer theſe two reciprocally graviating Powers to act againſt each other, it is plain, that the Water at the Orifice of the Tube I K, is by the lately mention'd difference of Weight between the two Columns P Q K I and R S T V, that is *b* leſs *c*, or 9 pound Weight (ſuppoſing all the Numbers to be as above) preſs'd or protruded downwards to Z.

Thus we ſee the Force wherewith a Syphon flows, deduced from the aforeſaid Principles, and the Fact is obvious to every one.

But we muſt beg our Readers to take notice here, as well as to remember hereafter, that we do by no means pretend that theſe Numbers of 100, 1, 10, *&c.* are the juſt Proportions of the Weight of Water and Air; but that we only mean thereby, to ſhow that a Column of Water is much heavier than a like Column of Air, and to conſult the eaſe of thoſe who are not accuſtom'd to Letters in Calculations.

SECT. LI. *Of a Fountain that Spouts or Springs higher than the Water that ſupplies it.*

LIII. Let us now propoſe an Inſtance that is a little more compounded than the former.

How to make a Fountain whoſe Stream riſes much higher than the Water above in the Ciſtern, which cauſes it to ſpring out without the Application of any Force Pumps, Bellows, or other Inſtruments, and without any other Means whatever, ſaving the Gravity or Weight of the Water itſelf.

This may be done after the following manner.

A B C D (*Tab.* XXVIII. *Fig.* 2.) is an open Ciſtern, from which an open Tube N R is carried downwards thro' the Covering E H of another Ciſtern E F G H, ſhut ſo cloſe that no Air can get in, paſſes down to R, almoſt to the Bottom of the Ciſtern F G.

From the upper Part of this loweſt Ciſtern E H, there riſes a ſecond Tube S T, paſſing on almoſt as high as T D, or the Lid of a ſecond Ciſtern D C K I, which is likewiſe cloſed; and from thence there is again derived a third Tube to

L M Q,

L M Q, which is ſtopt with a Cock that has a large Orifice at M O.

Moreover in the Ciſtern D C K I, there is a Hole at P, which can be open'd and ſhut by another Cock or Stopper.

To ſet this Machine to Work:

Pour in Water at the Orifice P into the Ciſtern D C K I, till the Tube L Z Q O be full, ſhut the Cock M O, continuing to pour in Water at P, till the Water riſes in the ſaid Ciſtern to the Height T Y, or level with the Mouth of the Tube T.

Then ſhut the Cock P, and pour Water into the Ciſtern A B C D till it riſes to the Height 2 T. This is not indeed abſolutely neceſſary here, but is preſcrib'd to the End, that by taking the ſame Height of Water in both the upper Ciſterns, the Calculation may be the more Simple, and conſequently more Intelligible to unexperienced Perſons.

This being done, and every Thing at Reſt, upon opening the Cock M O, you will ſee the Stream of Water riſing up to V thro' the middle Orifice of the flat Plate 5 *6*, or at leaſt to a very conſiderable Height above the uppermoſt Superficies 2 T of the Water which is in the Ciſterns A B C D, and D C K I, and which preſſes up the Stream *6* V.

It muſt be here obſerv'd, that foraſmuch as the Water of the upper Ciſtern A B C D deſcends into the lower E F G H during the Play of the Fountain, there muſt be a Hole in the latter from whence the Water may be diſcharged, which being done, it muſt be ſtopt again, if you would play the Fountain again.

Or otherwiſe (which I find moſt convenient in mine) you may place a little Pump at 2 thro' the Tube N R, down to the Bottom F G, and then

Pump the Water out of the lower Ciſtern E F G H thro' N, the Cock being open'd in the Ciſtern D C K I.

To know then with what Force the Stream riſes from the Cock N O, or the Orifice *56*:

Let the ſaid Cock be turn'd or ſhut again, whereupon the upper Ciſterns and Tubes being fill'd with Water, all will be ſtill; and let it be ſuppos'd (that we may not repeat the ſame) that all the Tubes as well the real ones N R, T S, L Z, as the imaginary ones W 2, X 4, and 45, are of the ſame Width. Tho' this likewiſe is only requir'd for Calculation ſake, ſince we may otherwiſe uſe for this Purpoſe, ſuch a Part only of a larger Tube as is equal to the Width of a ſmaller.

Let then W X be the uppermoſt Plane of the external Air; and let that of the Water T Y be continued to 4. Conſequently, as we have ſhewn before, the Part 2 of the Superficies of the Water in the upper Ciſtern A B C D, will be preſs'd downwards by the Column of Air W 2.

Let us again call the Weight of the ſaid Column *a*, or 1000 Pounds.

After the ſame manner we will term the Weight of the Water-Column R 2, *b*, or 100 Pounds; as alſo that of the Air-Column T 3, *c* or 10 Pounds too: The ſecond Water-Column Y Z ſhall be expreſs'd by *d*, or 80 Pounds, and the ſecond Air-Column 4 M by *e*, or 8 Pounds.

To proceed then.

The Part R of the Horizontal Plane R 3 is preſs'd downwards under the Tube N R by the Weight of the Air-Column W 2, or *a*, otherwiſe 1000 Pounds joyntly with that of the Water-Column 2 R, otherwiſe *b*, or 100 Pounds; and conſequently by *a* and *b* together, or by 1100 Pounds.

But all Things being quieſcent, we know according to the foregoing *Sect.* XLIII. that with the ſame Force as R is preſs'd downwards, the equal Part 3 is preſs'd upwards; ſo that the Force which drives the Part 3 upwards, is likewiſe equal to *a* added to *b*, or 1100 Pounds together.

Now the Air-Column T 3 nam'd *c*, and ſuppos'd to be 10 Pounds, does alſo gravitate with the ſame Force upon 3 downwards. Wherefore Subſtracting this downward-preſſing Weight *c*, or 10 Pounds, from the Force that preſſes 3 upwards, or from *a* and *b*, that is 1100 Pounds, the Force with which the whole Air-Column T 3, and conſequently alſo its Superficies T, by the Difference of both theſe acting Powers is moved upwards, does reſult from thence. And the ſame muſt be expreſs'd by *a* and *b* together, leſs *c*; or by 1100 leſs 10, that is by 1090 Pounds.

Again, ſince T is a Part of the Air's lowermoſt Horizontal Plane T Y, which Air preſſes upon the Water in this Ciſtern D C K I, and ſince Y is an equal Part of the ſaid lowermoſt Horizontal Plane, it follows according to the abovemention'd Laws of Hydroſtatics, that Y is preſs'd with as much Force downwards as T upwards; ſo that Y is preſs'd downwards with a Force equal to the ſaid *a* and *b* together, leſs *c*, or with 1090 Pounds.

To which if we here add the Weight of the ſecond Water-Column Y Z, that is, of *d*, or 80 Pounds, the Part Z 9 will be preſs'd more ſtrongly downwards with this Weight than the Part Y; and conſequently the Weight which preſſes Z 9 downwards, will be equal to *a*, *b* and *d* together leſs *c*, or 1000, 100, and 80 together, leſs 10; that is, 1170 Pounds.

And ſince Z 9 and M O are equal Parts of the Horizontal Plane Z O, M O, preſs'd with the ſame Force upwards.

If now the Cock at M O had no conſiderable hickneſs, and yet hinder'd the Water from ſpringing out, it would appear that M O were preſs'd downwards with the Force of the whole Air-Column M X, that is of X 4, *a*, or 1000 Pounds (for this is equal to W 2) and 4 M, *e* or 8 Pounds, that is, taking in all together, M O is preſs'd downwards by *a* and *e* together, or 1008 Pounds.

And it has been ſhewn before, that it is preſs'd upwards by *a*, *b* and *d* together, leſs *c*, or by 1170 Pounds.

Wherefore if we ſuffer theſe up and downward-preſſing Powers to operate on each other, as they do, when the Cock is open'd at M O; it is plain that the Water which preſſes upwards at M O being ſtrongeſt, will over-ballance the oppoſite Power that preſſes the ſaid M O downwards, and be driven upwards by the difference of the Powers acting againſt each other.

This Difference is found by Subſtracting the ſmalleſt downward-preſſing Force *a* and *e* together, or 1008 Pounds, from the greateſt *a*, *b* and *d* together, leſs *c*, or 1170 Pounds.

So that the Difference, or the Force wherewith the Water aſcends at M O, is equal to *b* and *d*, leſs *c* and leſs *e*, or to 162 Pounds.

Or to expreſs the ſame by Words that may be apply'd to the Fountain, and to take theſe Things for the Letters which they denote: The Water will be protruded out of the Cock M O with a Force equal to the Weight of both the Water-Columns 2 R and Y Z, Subſtracting the Gravity of the two Air-Columns T 3 and 4 M.

Now ſince the Weight of the Air with Reſpect to that of Water, is as $\frac{1}{1000}$, it may be omitted in this Calculation, as making no conſiderable Alteration therein. And we may advance, without committing any Miſtake worth notice, that this Fountain ſpouts with as much Force, as if the gravitating Water in the Ciſtern had the Height of both the Water-Columns 2 R and Y Z, that is, of *b* and *d* placed one upon the other.

So that from hence it is eaſie to infer, why the Stream M V ſprings much higher than the higheſt Water A 2 in the Ciſtern, ſince the Height thereof alone is equal to that of a Water-Column 2 R in this Contrivance of a Fountain. And that Experience agrees with theſe Propoſitions, every Body that pleaſes to try, will find as well as we.

SECT. LII. *Of a Fountain of* Hero, *the Stream whereof is longer than the Fountain high.*

LIV. SOME Years ago, I caus'd to be made another kind of a Table-Fountain, of the Nature of that *Hero Alexandrinus*; but with this Difference, that whereas in that of *Hero* it is not poſſible to make the Stream that ſpouts out to attain to the Height equal to that of the Fall of the Water, or of the Fountain itſelf; yet in mine, notwithſtanding the Height of the Machine, was no more than 3½ Foot, the Jet roſe ſtrongly five Foot higher than the Water in the upper Ciſtern.

The Structure is thus: G A F H (*Tab.* XXVIII. *Fig.* 3.) is the uppermoſt Ciſtern, being open, and having under it two ſmaller, and every where Air-tight Ciſterns A B C D, and D C E F; each of theſe has an Orifice or Hole, one at M, t'other at N, and both of 'em may be render'd alſo Air-tight, by ſtopping them with a Cork cover'd with a wet Bladder, or a Cock. There are likewiſe two cloſe Ciſterns below, S T R P, and P R Q O. From the Bottom A F of the uppermoſt Ciſtern G A F H, there paſſes a Tube K I downwards almoſt to the Bottom R T of the Ciſtern P R T S; but in ſuch a manner that the ſame, or whatever it contains, has no Communication with the Ciſtern D C E F through which it paſſes. And from 3 in P S, there is carried a Tube 3 L upwards, juſt below the uppermoſt Plane D F of the Ciſtern D C E F; from the Bottom of which C E, there deſcends again at *9* a Tube at *9 h*, terminating in the other Ciſtern Q O P R very near the Bottom of it Q R. And this ſame Ciſtern Q O P R ſends again a Tube 4 Z upwards, which beginning at 4 is carried on to Z, exactly under the uppermoſt Plane A D of the Ciſtern A B C D. *Laſtly*, At A D there is a Tube *p r* cloſe ſolder'd at 5 *6*, which riſes to *r b* only, or a very little higher than the Plane A D; and paſſes downwards to P, or nearer to the Botton B C.

On the Top of this laſt Tube, we fix'd another *r* 8, which at W 8 was cover'd with a flat Plate, having a ſmall round Hole in the Middle of it, thro' which the Stream was to paſs, and we clos'd it at the Joint *r* with *Emplaſtr. de Minio*, ſo that it was impervious either to Water or Air.

Now to ſet this Machine to Work:

We inverted or turn'd it upſide down, ſo that the Ciſtern G A F H was undermoſt, and having fill'd both the Ciſterns A B C D, and D C E F with Water at the Orifices M and N, we ſtopt the ſaid Orifices very cloſe with a Cork and Bladder, putting a Finger in the mean time upon the Hole in the little Plate W 8, to the end that the Water pour'd in at M, or ſo much of it was above *p*, might not run out.

Then ſuddenly placing the whole Machine in its former State, ſo as that the Ciſtern G A F H was again uppermoſt, we pour'd without delay ſome Water that was at hand in the ſaid Ciſtern;

ſtern; whereupon, preſently afterwards, we ſaw a Stream 8 7 riſing out of the Tube *r* 8 thro' the little Hole, which Stream when meaſur'd was much longer than the Height of the whole Machine, as has been already ſaid.

It will not be neceſſary to give an Account here, how the Water ſubſiding, or ſinking from G A F H thro' the Tube K I preſſes the Air out of the Ciſtern P R S T thro' the Tube 3 L upwards, which finding no room any where but by preſſing downwards the Water in the Ciſtern D C E F, and in the Tube Y *h*, protrudes the ſaid Water towards the Ciſtern O Q R P with a much greater Force than that of its own or ſingle Gravity. At which Place the Water likewiſe aſcending, the Air is protruded with the ſame Force from O Q R P thro' 4 Z to the Ciſtern A B C D, which (without counting the Air in the Tubes L *g* and Z *v* becauſe of its Levity, and ſmall Reſiſtance) cauſes the Water to ſpring out of the Tube *p* 8; after this manner with almoſt the Force of both the Weights of the Water-Columns Y *h* and K I. In the ſame manner we may deduce the Operations of the foregoing Fountains, Syphons and others, whereby, without any Calculation, we may alſo Form a general Idea of their Properties. I thought it ſufficient to give my Readers one only Inſtance here, it not being my Deſign to write an entire Syſtem of Hydroſtatics. They who would impute the Force wherewith the Water iſſues out of the Fountain exactly, may do it after the Method of the aforemention'd Examples.

But before I proceed any further, I muſt add, that this Machine may be form'd after a much more convenient manner, ſo as that one need not invert it, nor yet ſtop the little Hole of the Column W 8 with the Finger, or any thing elſe; this may be done by Stop-Cocks in other Places, and by making the Orifices M N above at A F, as is known to every Body that has any Skill in theſe and other kinds of Water-Works. Yet I have rather choſe to expreſs it in the preſent manner, becauſe it is that in which I made the Experiment, and in a Place where we could form this whole Structure of no other Metal than Tin, nor could have the Aſſiſtance of ſuch Workmen as are neceſſary in ſuch Matters. Whereas the other Fountain was prepar'd by a Perſon of good Judgment, and who was well inſtructed concerning the Frame and Make thereof.

Nor will it be difficult to one that rightly underſtands this, and the foregoing Diſpoſition of a Fountain, to cauſe a Stream of Water to riſe up to a given Height by a requiſite Multiplication of Ciſterns and Tubes, the Height of the Deſcent of Water being likewiſe given. It is certain at leaſt, that all this may be deduced by Argumentation, and confirmed by Experience.

SECT. LIII. *The Motion of Water in a Curve Tube.*

LV. IN the laſt Place we ſhall add ſomething, which, tho' of little Importance, yet at firſt Sight has appear'd wonderful even to ſome Mathematicians themſelves, to whom we have ſeveral times communicated it; and which ſerves to confirm the foregoing Laws after a ſtrong manner.

Y *m n* Z is a Ciſtern or broad Veſſel (*Tab.* XXVIII. *Fig.* 4.) fill'd with Water up to the Brim; P O N M is a Cylindrical Glaſs, with the Bottom P O upwards, and the Mouth M N juſt under the Surface of the Water in the Ciſtern, and containing before it was inverted, ſome Water in it, which (the Mouth of the Glaſs being thus turn'd downwards,) continued ſuſpended therein at the Height Q R.

Moreover L B V is a Curve Tube, both Legs of which being fill'd with Water to the ſame Height L and *r*, I put my Mouth to the Orifice V, and blow'd it back from *r* to A, thereby cauſing it to run out at L.

The Water by this means being contain'd between L and A, to prevent its ſubſiding at L, and riſing at A; I preſently ſtopt the Orifice V with my Finger, whereby the Water remain'd ſo much lower at A than at L.

Then I put the ſaid Tube L B A under the Glaſs M N O P, ſo that a Column T L of Water, (and the Glaſs being not quite full) a Column alſo of Air *u* T was above the Orifice L.

Thus the Water being at unequal Heights in the Tube, under the Glaſs, and in the Ciſtern; (foraſmuch as that in the Leg of the Tube L B, was not only the entire Length S L or A *r* higher than in the other Arm *h* V; and beſides the Water-Column T L preſs'd yet more upon the Orifice L, without counting all the Air T *u*,) Who could at firſt ſight, unleſs he were well vers'd in *Hydroſtatics*, imagine otherwiſe, than that by the greater Height of Water, at S L, or rather at S T, the Water would be forced upwards at A, when the Finger was remov'd from V.

And yet we find by Experience, that inſtead of A riſing to *r*, the Water will ſubſide from A to F, as ſoon as ever the Finger is taken from V.

To diſcover therefore the Reaſon this Phenomenon, ſo ſurprizing to ſome People, nothing more is neceſſary than to trace the ſame back to the before-eſtabliſh'd *Laws* of *Fluids*, when you have again blown the Water down to A, and ſtop'd the Orifice V, and reduced all to its former State.

Let us then again ſuppoſe W X to be the upper Superficies, and A E a Horizontal Line drawn parallel to Y Z. Now let the Air-Column W E equal to X A (the Finger being remov'd from V) be each call'd *a*, and the little Water-Column A F becall'd *b*; and the little Air-Column G E of the ſame Height with A F, be *c*; each of the Water-Columns H *g* and D T be *d*; and the little equal Air-Columns *t g* and *u* T be *e*: Whereby, according to the foregoing Method, the Force may be computed with which the little Water-Column A F is preſs'd down to F, or to the Depth Y Z.

But this may be likewiſe more briefly done after the following manner: The Part G is preſs'd by the Air-Columns W E and E G, or by *a* and *c*; but (according to *Sect.* XLIII.) the Part F lying in the ſame Horizontal Plane Y Z, is preſs'd upwards with the ſame Force *a* and *c*, when upon ſtopping the Orifice V with the Finger, all is ſtill; foraſmuch as there can be drawn a Thread from G to F, without paſſing thro' any other Solid or Fluid Matter: But if now you remove the Finger from V, the Part will be preſs'd down by the Air-Column X A *a*, and the little Water-Column A F, *b*; ſo that the Force which preſſes F upwards, is *a* added to *c*, that which preſſes the ſame downwards is *a* added to *b*.

Now ſince *b* is Water, and *c* Air, the downward-preſſing Force upon F, or *a* added to *b*, is greater than the Force preſſing upward expreſs'd by *a* and *c*; and conſequently the Part F is preſs'd downwards by the Difference of this Force, or by the Force of Gravity wherewith the little Water-Column exceeds the equal Air-Column E G, that is by *b* leſs *c*.

From whence it appears, that whilſt A F or *b* is Water, and heavier than G E or *c*, which is Air, the Part F, and conſequently the Column A F, will be preſs'd or move downwards, and never ceaſe till A ſubſides to F, and the Column A F becomes Air likewiſe.

And then the Difference of A F and G E, or *b* leſs *c* will be nothing, and the Force preſſing up and downwards upon F, equal; for which Reaſon the Water in the Tube V *h* will not be higher than at F, or equal to Y Z, when all is quieſcent by its Weight only. And the ſame is conformable to Experience.

We might here ſubjoyn the Demonſtration, that if L the Orifice of the Tube L B V ſtood out at any Height above the Water Q R in the Air P Q O R, the Water would not ſubſide ſo low as F or Y Z, but that it would remain and reſt proportionably as much higher above F or Y Z, as L ſhould be above Q R.

I cannot forbear ſhewing here, how neceſſary the laſt Obſervation made (*Sect.* XLIII.) is in this Calculation; to wit, that ſince the Orifice L of the Tube L B V, being under the Water at Q R, a Thread can be drawn from G to F, that paſſes thro' no other fluid Matter than this Water; we may preſently diſcover after a much ſhorter manner the Preſſure upwards of F, by the Preſſure downwards of G.

But when the Mouth L of the Tube L B V happens to be above the Water Q R, in the Air P Q O R, we ſhall find that the Thread which we would have drawn from G to F, muſt firſt paſs thro' the Air P Q R O out of the Water to the Orifice L, before it reaches F; for which Reaſon the aforeſaid ſhort or abridg'd Computation can't be made true, ſince, for this Reaſon, F and G will not be preſs'd with equal Force upwards and downwards, the Finger being upon V, tho' they be equal Parts of the ſame Horizontal Plane. This will appear clearly to every one that ſhall compute it after the manner of thoſe Examples mention'd, *Sect.* LX, and LXI.

But this may ſuffice to give a ſhort experimental Example of theſe *Laws* of *Hydroſtatics.*

This Experiment may be made with little Trouble or Charge, if you put a Curve Glaſs Tube in an Ounce Viol almoſt full of Water, adapted to the Mouth of the Viol, that no Water can run out of it when inverted, or turn'd upſide down.

SECT. LIV, LV, LVI *A Hydroſtatical Paradox ſhown by two Experiments.*

LVI. NOW that theſe many thouſand Parts of which Fluids conſiſt, how ignorant ſoever of what they are doing, obſerve ſo accurately theſe Laws of *Height*, that before they depart from them, they produce Effects incredible to many Perſons, will appear from what follows.

Let (*Tab.* XXVIII. *Fig.* 5.) D C be a round ſtreight Tube, of as great a Length and Breadth as you pleaſe, in which two other Tubes A C and B C do open, or even as many more Tubes as the Circumference of the firſt Tube D C will contain, and theſe alſo may be as large as you will; but for the ſake of Plainneſs, we will ſuppoſe there to be no more than three, and of equal bigneſs.

Then fill all theſe Tubes with Water to an equal Height, which upon opening the Cocks G, E, F, will preſs upon the Baſe C of a Veſſel of Communication C T H fitted to the Cocks and Tubes; and upon removing that Baſe or Bottom woul'd run out thro' C.

Now according to the foregoing Laws, it is obvious to all that underſtand *Hydroſtatics*, that, if all the Cocks G, E, F, be ſhut, and upon opening

ing any one of them, the Water contain'd in each of theſe Tubes ſeverally will preſs on the Bottom C with the ſame Weight; and that therefore if the Water in D C only (ſuppoſing the Cock E open, and G and F ſhut) preſſes on the Bottom C with the Weight of 100 Pounds, the Water in the Tube A C only (the Cock G being open, and E F ſhut) will preſs the bottom C with the ſame Weight of 100 Pounds; and ſo likewiſe will the Water in the Tube B C.

Now ſince the Water in each of theſe Tubes does alone, and without the Weight of the other two, preſs upon the Baſe C with 100 Pounds; let one who has never ſeen theſe *Hydroſtatical* Experiments, nor heard of 'em, ask himſelf with what, or how much Weight all the Water in the three Tubes acting jointly, and the three Cocks being open, will preſs upon the Baſe C; and let him tell us, whether he do not find himſelf at firſt diſpos'd to anſwer (as I have known many learned and ingenious Men do) that ſince the Water in each ſingle Tube preſſes upon C with 100 Pounds, all three of 'em operating together, will preſs with thrice the Weight, excepting the little Water at T H F E G, which lies between the Cocks and the Bottom C, and always remains the ſame; which however, if the Tubes be taken long enough, makes no remarkable Difference.

But in caſe we ſhould tell him: *Firſt*, That far from anſwering rightly, he has quite miſtaken the Matter; and that altho' the Water in each of theſe Tubes does ſingly preſs upon the Bottom C with the full Weight of 100 Pounds; yet when all three of 'em act upon the ſaid C together, the Preſſure is no more than of 100 Pounds, even though the Tubes were larger, and more numerous, and conſequently contain'd in them a greater Weight of

Water; for Inſtance, if each Tube like N B F were of the Size and Figure of N F R, or any other; provided only that the Water in each of the Tubes ſhould continue at the ſame Perpendicular Height D H, or R S, and the Baſe which bears the Preſſure, of the ſame Extent.

And *Secondly*, that the ſame happen'd by virtue of the aforemention'd Hydroſtatical Law, that no Part, as T H, of a Horizontal Plane T S, does ever bear a greater Burden than the Weight of the Column of Altitude, which has T H for its Baſis, and D H or R S for its perpendicular Height: He will ſee indeed that this is a juſt Conſequence of this Law; but undoubtedly alſo confeſs, that the manner after which the Water muſt be diſpos'd in theſe three or more Tubes, ſo as not to gravitate more with a triple or greater quantity of Water, than with one third thereof, is unknown to him.

The rather, ſince he ſees that ſuch Preſſure is perform'd not by a Fluid actually put in Motion, but by a quieſcent one.

LVII. And to the end, that they who read this, ſhould not doubt of the Truth of the Experiment, which, unleſs they were thoroughly vers'd in *Hydroſtatics*, they could hardly avoid, let them pleaſe to compare the following Experiments therewith, which are only made to ſupport the Truth of the former againſt thoſe who queſtion it. I find them thus deſcrib'd among the Experiments which I noted ſome Years ſince on my Journal.

I caus'd a Machine to be made after the following manner: M N Q R (*Tab.* XXVIII. *Fig.* 6.) is a Tin Tube having a Cock at K, which can ſtop and open the Communication between the upper and lower Part of the Tube. From this Tube at S, there riſes another oblique one T S, growing wider and wider to the Top O T P, after the manner of a Funnel, having likewiſe a Cock at L, which can open and ſhut a Paſſage between the Fluid that is above and below it; at the end of this tin Tube at Q R, there is another Glaſs one Q R G H ſtuck into the former, and both clos'd together with *Empl. Diachylon.*

Then I took a large Cylindrical Glaſs A E F B, and fill'd it up to C D with a ſtrong Pickle, and binding the tin Tube together with the glaſs one, faſt to a tranſverſal Piece of Wood X V; being empty, I let them down into the Pickle to a certain Depth.

Whereupon pouring gently ſome Oyl of *Turpentine* into the Funnel and Tube (both Cocks being open) after that a part of it ran out at G H, and produced a Cream of floating Oyl upon the Pickle at A B C D, we found that the ſaid Oyl being lighter, and conſequently kept up by the Weight of the Pickle, at M N O P, for Inſtance, or at leaſt much above the Superficies of the Pickle, remain'd in that Condition in the ſaid Funnel and Tube.

Having then ſtay'd till all was perfectly ſtill, we obſerv'd a drop of Oyl hanging below at the Bottom of the Glaſs Tube G H, which immediately, upon pouring ſome little quantity of Oyl into the Funnel at O, or the Tube at N, by ſuch a ſmall acceſſion of Preſſure fell off from G H, and emerged in the Pickle. After which (the piece of Wood V X being ty'd very cloſe to the Glaſs Veſſel, that it might not ſtir) when another Drop of Oyl was hanging at G H, we ſoftly turn'd both the Cocks at K and L, and made them faſt; and then found that whether one or both of 'em were open'd, the Preſſure was not ſo much alter'd, as to cauſe this ſuſpended Drop of Oyl to fall off, tho' we had ſeen before, that it always ſo happend by the addition of a ſmall Weight, which was not to be compar'd to that of the Oyl in the Funnel.

From whence (not to recapitulate all the Conſequences deducible from the many *Hydroſtatical* Laws which we have before laid down and proved) it appear'd that the Preſſure of the Oyl in the Tube N H, was neither increas'd nor diminiſh'd; whether it was that the Preſſure of all the Oyl which was in the Funnel S P O, acted and preſſed downwards, or whether it was hinder'd from doing ſo by the Cock L.

LVIII. For the ſame Purpoſe we joyn'd a Curve Tin Tube D E F, to the preceding Inſtrument B C D, and ſticking into it a Glaſs Tube F A, clos'd 'em together as before at D and F. Then the Cocks being open, we pour'd common Water into the Funnel C, till it roſe to the ſame Height A B C in the ſaid Funnel, and both the Tubes A and B: And moreover having open'd and ſhut each of the Cocks K and L, and afterwards both together, we could not obſerve the leaſt ſinking or riſing at A; ſo that it alſo appear'd from hence, that the Preſſure of the Water in the Tube B D, whereby the Water in E F was ſuſtain'd at the Height A, and did neither increaſe nor diminiſh, but continued entirely unalterable, whether the Water in the Funnel gravitated on it downwards or not.

From both which Experiments, what is ſaid above in *Sect.* XLIV, ſeems to be ſufficiently confirm'd, as ſtrange as it may otherwiſe appear to any one at the firſt Sight, altho' it be obvious enough to ſuch as underſtand *Hydroſtatics.*

SECT. LVII and LVIII. *Another Hydroſtatical Paradox confirm'd alſo by an Experiment.*

LIX. ANOTHER Inſtance concerning which, even the greateſt Mathematicians freely own their Ignorance (or at leaſt their Uncertainty) as far as relates to the Manner of the Water's working: We will here offer, not according to the little Meaſure of the Inſtruments wherewith we perform'd it, but as in the former, ſo as to render it more Intelligible, and to make a greater Impreſſion.

Let A B L M (*Tab.* XXIX. *Fig.* 1.) be a Veſſel repreſented here in its Profil or Section; and for the ſake of Perſpicuity ſuppos'd exactly Square, and the Dimenſions of its Length and Breadth to be 12 Foot: This Veſſel muſt likewiſe be ſuppoſed to be ſhut cloſe with a flat Horizontal Covering A B, of the ſame Breadth, having at V R a leſſer ſquare Orifice, in Length and Breadth 2 Inches, or $\frac{1}{6}$ of a Foot, from whence there riſes a ſquare perpendicular Tube R Q S V, of the ſame Breadth and Wideneſs with the little Hole V R, but its Height Q R of 36 Foot; let the Height of the Veſſel W A be eight Inches or $\frac{2}{3}$ of a Foot.

Below, at W Z, the Ciſtern A B W Z is quite open, but there is a looſe wooden Bottom Frame lying upon the Brim of the Ciſtern M N, L O, tolerably ſtrong and inflexible, and ſo placed, that when the Water is at any height, nothing can paſs between the Frame and the ſaid Bottom. We had put under a much ſmaller Bottom, which we had uſed for this Purpoſe, a thick wet Piece of Leather, which lay upon the Points of the upwards-bent Tin Brim O and N, and which by the Gravitation of the Water upon the wooden Brim being preſs'd downwards, kept the Water intirely in the Ciſtern.

There was beſides a Ring faſten'd at E in this Bottom, from which a String paſſing thro' the ſquare Tube, was ty'd above at F, to one end of the Ballance H G F; ſo that by drawing the ſaid String F E upwards, the ſaid Bottom W Z could be rais'd up at the ſame time.

Then pouring Water into the Ciſtern A B Z W, up to the Brim A B, it is plain that the Length and Breadth of the ſaid Ciſtern being 12 Foot, the Area thereof will contain 144 Foot, which being multiply'd by the Height A B or $\frac{2}{3}$ of a Foot, or 8 Inches, the ſolid Contents of this Ciſtern, or of the Water in it, will give *96* Cubical Feet, weighing (if you allow *63* Pounds to a Cubical Foot of Water) *6048* Pounds.

Wherefore the Weight I, equal to ſo many Pounds, being put into the Scales ſuſpended at H, the ſame (if you except the Weight of the Bottom W Z, and the Friction beſides) will equiponderate the Water in the Ciſtern A B W Z; and if it were but little more augmented, it would be able to raiſe the Bottom W Z with all its Water A B, tho' neither the Cover or Lid A B, nor the Tube R Q S V, were over the ſame. And this whole Matter is obvious to every Body.

But if we proceed farther, and do alſo fill the ſaid Tube with Water, which Tube being 2 Inches or $\frac{1}{6}$ of a Foot Wide, and *36* Feet in Length, it will exactly contain a cubical Foot, or *63* Pounds of Water, according to the foregoing Suppoſition.

This being done, ſince the looſe Bottom W Z may be here conſider'd as a Scale ſuſpended to the Ballance F H at E, upon which the Water in the Ciſtern A Z, and in the Tube Q R, weighs againſt the Weight put into the other Scale ſuſpended at H; let any one that has not nicely obſerv'd theſe Singularities in *Hydroſtatics*, or been Converſant in theſe Matters, I ſay, let ſuch a Man retire, and ſeriouſly Reflect with himſelf, that, foraſmuch as the Weight I is in *Equilibrio* with the Water in the Ciſtern A B W Z (excluſive of the Cover A B, and the Tube R Q) ; and ſince the whole Tube Q R does alone contain a cubical Foot, or 63 Pounds, of Water; whether he might not ſafely enough conclude, that the Weight I being augmented by another Weight W, weighing conſiderably more than the ſaid cubical Foot of Water; for Inſtance, by adding 100, yea even 1000 Pounds thereto, the looſe Bottom W Z, or the other Scale with the Water upon it, might be very eaſily raiſed up; the rather, ſince the ſame is found to hold true in all ſolid Bodies, and even in Water itſelf, if turn'd into Ice, provided it were not frozen to the Sides of the Ciſtern or Tube; as is affirm'd by Monſieur *Varignon*, in the *Act. Lipſ.* 1692. p. 365.

But he that has read and conſider'd the above-ſhown Laws of *Hydroſtatics*, will ſee (*Sect.* XXXVIII.) that in the Horizontal Water-Plane A B, juſt below the Cover of the Ciſtern A B, the Plane V R is preſs'd by a cubical Foot of Water, or 63 Pounds; for which Reaſon every equal Part R *e*, *e f*, and V *m*, *m n*, of the ſaid Horizontal Plane, according to the ſaid Law, (*Sect.* XXXVIII.) the Water being quieſcent in the Tube and Ciſtern) will be preſs'd downwards equally in all its Parts; ſo that therefore this one Foot of Water, or 63 Pounds, in the Tube Q R, does equally gravitate on the looſe Bottom W Z, as all that quantity of Water that would enter into the Cavity A B T P, in caſe the Ciſtern A W Z B were a perpendicular ſquare

Veſſel of 36 Foot in Depth or Height, and 12 Foot in Length and Breadth.

Now we may diſcover the Weight which this Water would amount to, by multiplying firſt the Breadth and Length of the Ciſtern, or 12 Foot, by each other, whereby the Area or Baſe will contain 144 ſquare Feet. This being again multiply'd by the Height Q R or 36 Feet, makes the ſolid Contents of the Veſſel A B T P, 5184 cubical Feet; each of which being again ſuppos'd 63 Pounds, the whole Maſs of Water will weigh 326592 Pounds: With which Weight the looſe Bottom W Z is burden'd and preſs'd downwards by the little Water in the Tube Q R.

Wherefore far from raiſing the Bottom W Z by adding another Weight W (of 100 or 1000 Pounds either) to the Weight I in the Scale hanging at H, there wou'd be requir'd a Weight of above 326000 Pounds, only to equiponderate, or rather to put in Motion the 63 Pounds of Water thus diſpos'd in the Tube Q R.

And let no Body doubt of the Truth of what has been advanced, provided the Ciſtern be every where ſtrong enough to withſtand this terrible Preſſure. The Matter is well known to all the Moderns skill'd in *Hydroſtatics*, and has been Experimentally prov'd by many, as well as by us in ſmaller Veſſels.

LX. We don't only diſcover theſe Wonders in the Preſſure downwards of Fluids, but we Experience them too in the Preſſure upwards thereof, according to the ſame Laws; for ſince V R is preſs'd downwards by 63 Pounds when the Tube Q R is full, according to *Sect.* XXXVIII, every equal Part *e f*, &c. in the ſame Horizontal Plane A B will be preſs'd upwards with as much Weight, and conſequently the whole ſquare

Cover A B, will be rais'd up with the Force of 326500 Pounds, including the Orifice V R, and that which preſſes on it.

We have a remarkable Example of the latter in Mr. *Mariotte's Mouv. des. Eaux.* p. 106. He took a Tub A B C D, *Tab.* XXIX. *Fig.* 2. both Bottoms whereof A M D were bent inwards, and making a Hole in one at E, he placed in it the Tube E F of 1 Inch in Breadth, and 14 or 15 in Length, ſo that no Air could paſs between the Tube and Hole; then filling the Tub with Water, he ſet two Weights of 800 Pounds P Q upon it. After that he alſo fill'd the Tube with Water, and found that this laſt ſmall Quantity of Water did not only lift up the Lid or Bottom of the Tub together with the ſaid Weights, but likewiſe bent the ſaid Lid outwards; all which appear'd by a little Piece of Wood I L which was ſet for a Mark, and which almoſt touch'd the Tube at H; the ſaid Mark at H being rais'd above I L by the ſaid Preſſure upwards.

The End of the Experimental Demonſtrations, *&c.*

SECT. LIX. *Convictions from the ſurpriſing Force of Water.*

I LEAVE now an Atheiſt to conſider, whether this Law of Preſſure according to the Depth, and therein the dreadful Force of ſo ſmall a quantity of Water, ought not to be look'd upon as Wonderful; and unleſs Experience had prov'd the Certainty of it, whether he could have thought it credible, and whether he would not have rejected the Principles from whence it is deduced; and that he may ſee what the greateſt Mathematicians think thereof, let him conſult the *Act. Lipſ.* 1692. p. 365, and he will find that M. *Varignon*, whom the whole World allows to be ſo great a Mechaniſt, gives it the Name of a *famous Paradox*; of the Truth of which he ſays, the modern Mathematicians are ſufficiently convinced; but that they differ about the Manner according to which the ſame is produc'd by Fluids; and Mr. *Mariotte* calls it *a ſurpriſing Effect of the* Equilibrium. *Mr.* Whiſton *Prælect. Phyſ. Math.* p. 247, ſays of this Law (of which all theſe Wonders are plain Conſequences) that it is a well-known Rule in *Hydroſtatics*, but which has hardly yet been proved either Naturally or Mathematically; concerning which he gives us his Opinions in Liquids really moved, but not in ſuch as are ſtagnating; ſo that all the appearing Wonders are not yet compleatly ſolved thereby.

At leaſt it now ſeems, that no Atheiſt can come ſo far without charging himſelf with Folly, as to imagine that he is capable of proving that the Works of Nature muſt be cauſed or produced by a blind Neceſſity, which he is forc'd to own, he does not well underſtand; and which far from appearing to him as neceſſary, he muſt look upon as impoſſible, or abſolutely incredible, were it not that he was convinced thereof by Experience. And whether he can aſcribe all theſe Wonders (that are produced with ſo much Conſtancy and Regularity, that they plainly adapt themſelves to all the Conſequences that can be deduced by the Mathematicians from preceding Laws) to meer Chance, I leave to him to conſider.

SECT. LX. *Convictions upon another Foundation.*

I MUST add this in General hereto; that tho' many have endeavour'd to deduce both from the Laws of Mechanics, and particularly from the following: That in order to raiſe a Weight of a hundred Pound as high as one Foot, the ſame Force is requiſite, as to raiſe one Pound the the Height of a hundred Foot, at the ſame time; concerning which *Mariotte* and other Mathematicians may be conſulted; yet no Body has been able without Difficulty, to explain the Manner after which the Fluid Matters, even in reſt, adapt themſelves to obey theſe Laws to produce ſuch Wonders; and Mr. *De la Hire* (ſee his *Mechanique Prop.* 106. p. 331) and Mr. *Varignon* have very ingeniouſly invented a new kind of Levers, the Effects of which are ſo very analogous to the Powers of the Fluids, that being ſhut up into a ſquare Box or Cheſt, and put in order, gravitated or preſs'd againſt its Cover, Bottom, and Sides, after the ſame manner, as if the ſaid Box were fill'd with Water; but how great an Analogy ſoever may be proved from hence with Fluid Matters, neither thoſe Gentlemen, nor any Body elſe, can eaſily be perſwaded that Water, Oyl, or any other Liquids, owe their aforemention'd Motions to the like Machine.

SECT. LXI. *Without the Laws of Fluids, all Things would ſoon be in the utmoſt Confuſion.*

IN order to be convinced of that which happens in the World by this *Law of Preſſure* according to the Depth, let the Philoſopher who deduces every Thing from mere Chance, or a natural Neceſſity, attend to the following Matters which he may have already found to be true from the Premiſes, or if he be an experienced Mathematician, has been already aſſured of it by his own Study and Experience.

Certainly he will not be able to contradict this, namely, that all the Chambers of Houſes, from the meaneſt Cottages, to the Royal Palaces, would be nothing elſe but fatal Caverns and a heap of Rubbiſh to all that dwell it them, in caſe the Air ſhould exert its Gravitation and Preſſure, not like a fluid Matter, but like a Heap of ſmall ſolid Bodies, and conſequently that there were no other than a perpendicular Preſſure, without any Conſideration or Effect of the *Law of Preſſure* according to the Depth; whereby all the like Parts in the ſame Horizontal Plane are preſſed alike, whether the perpendicular Column of Air be great or ſmall, quite otherwiſe than what happens in accumulated ſolid Bodies. Let it be then conſider'd, what Confuſion and Miſery would be hereby occaſion'd to all Creatures that want a Shelter againſt the Inclemency of the Air, ſuch as Cold, Wind, Rain, *&c.*

To repreſent this yet more plainly, let it be ſuppoſed that ſome Body is ſitting in a Chamber W (*Tab.* XXIX. *Fig.* 3.) and is cover'd with a Ceiling thereof A B C, the Height of which from his Mouth by which he breathes, is as M O; and the Height of the external Column of Air which has a Communication with that in the Chamber, is as Q S. If now there were no greater preſſure of the Air at L M, than from that Column thereof which is here repreſented by L N O M, (as it would happen if the Air gravitated like ſolid Matters) the Preſſure thereof would be very ſmall, and conſequently the Elaſticity, as ſoon as the Air ſhould be rarified by the removal of the Preſſure to which it is uſed to accommodate itſelf.

For ſince the Mercury in the *Barometer* T, is uſually rais'd to 28, 29, 30, or 31 Inches, by the external Air P Q S R, which Mercury is fourteen times heavier than Water; if we ſuppoſe the Height of the Mercury to be 30 Inches, there will be required fourteen times 30, that is, 420 Inches of Water to balance the Air; and ſince Water is commonly found to be 800, 900, or 1000 times heavier than Air (ſuppoſing this laſt Sum to be trueſt) the Air being compreſſed in the ſame manner as it uſually is with us, the Height of it will be 1000 times 420, or 420,000 Inches (for we take no notice here of that greater Height which it may have upwards, becauſe of the leſſer Weight it bears, and conſequently is more expanded) and then we muſt ſuppoſe Q S to repreſent the aforeſaid Height.

For Conveniency ſake, let us now ſuppoſe N O to be the Height of 14 Foot, that is 168 Inches; accordingly the Depth of the Chamber A D or B K muſt be computed at the rate of 18 or 19 Foot at leaſt, which is higher than common Chambers are uſed to be; and the Preſſure of the Air at L M, which is the Weight of the aforeſaid Column of Air L M O N of 14 Foot or 168 Inches, Is to the Preſſure of the external Air P Q, As the Column L M O N, Is to the Column P Q R S; or As 168 To 420,000 Inches, or juſt As 1 To 2500.

Conſequently the Preſſure at L M within the Chamber, is only as $\frac{1}{2500}$ Part of that which happens at P Q by the Air out of the Chamber. Now this laſt raiſes the Mercury in a Barometer up to 30 Inches, according to which the Air in the Chamber at L M, would only raiſe the ſaid Mercuryup to $\frac{3}{220}$ or ſcarce $\frac{1}{83}$ Part of an Inch, or about $\frac{1}{7}$ of a Line which is $\frac{1}{12}$ of an Inch.

This being ſuppoſed, every one that ever ſaw a living Creature put under the Receiver of an Air-Pump, near which a Barometer was likewiſe placed, has been convinced with the utmoſt certainty, that long before the Mercury ſubſided down to $\frac{1}{7}$ of a Line, that Creature would fall into Convulſions, and for the moſt part expire too.

So that from hence, and other Experiments made by the Air-Pump (one of which we have quoted above in the XVII*th Contemplation* from Mr. *Otho Gueric*, which had almoſt coſt a Man his Life) it is plain enough, that if the Air in the Chamber at LM, bears no greater Preſſure than that which happens to it from the Height of the Cieling ON, all the Creatures that live either upon the Earth, or in the Air, would immediately die in the ſaid Chamber. And that all Chambers and Houſes would therefore be uſeleſs, were it not alone that this great Inconvenience is prevented by the aforeſaid *Law of Preſſure*, every way according to the Depth of the Fluid, to which all fluid Matters obey, and by which the Preſſure in the ſame Horizontal Plane P M is equally ſtrong upon the like Parts P Q and L M, whether within or without the Room.

For the ſame Reaſon it would not be poſſible that a Ship could go under a Bridge without occaſioning a ſudden Death to all that were therein. No Fiſh could even ſwim under a Bridge without being in danger of loſing its Life, becauſe the Air that is under a Bridge, would gravitate much leſs upon the Water; juſt as it happens to ſuch Fiſh that are put into the Air-Pump, when the Air is beginning to be exhauſted from thence, when the Rarefaction of the Air, and the Diminution of its Preſſure upon the Water firſt puts them into Convulſions, and ſoon after kills them; that the ſame does not likewiſe happen under every Bridge, is alone owing to the Laws of *Hydroſtatics.*

To this may be added, that the Air at L M in a Chamber undergoing ſo ſmall a Preſſure, that it can hardly keep up the Mercury in the Barometer to $\frac{1}{7}$ of a Line, wou'd become ſo thin, as to be uncapable of conveying Sounds to their Ears, of which we have already given Inſtances in the XVII *Contemplation*; ſo that tho' one ſhould be able to live in ſuch an Air, yet no Man could ſpeak to another therein: Not to mention that Fire will not burn in ſuch a thin Air, nor Smoak aſcend; that none of the Particles which are the Object of Smelling, could paſs from any Bodies to us, beſides many other Things which wou'd be occaſion'd by the Thinneſs of the Air.

If againſt this it ſhould be objected, that altho' the Air in the Chamber undergoes ſo little Preſſure and Expanſion, yet the more compreſſed Air would run thither from P Q R S; as Water it ſelf would do, tho' there is little or no Elaſticity in it, if it were in the place of the Air. To which we anſwer, that this Objection has no other Foundation but the very Action of Gravity, and *the Law of Preſſure, &c.* which is only peculiar to Fluids, which in this Caſe we do not ſuppoſe to obtain, ſince we only endeavour to ſhew what would happen if the Particles of Air operated by their Gravity, not like Fluid, but other ſolid Bodies.

To Illuſtrate this Matter, let *Tab.* XXIX. *Fig.* 4. be a high Sand-bank (only conſiſting of ſolid Bodies for that Reaſon) and of the Figure repreſented here by A B C D M H N; 'tis plain then, that the Body G is preſſed with the Sand above it at E F C D, and if you will, with that on the ſide of it at Q R; but if there be in the ſame Horizontal Plane B H, another Body equally as big as K, which is no more than a Hands breadth L S below the Sand, every one knows, that this K bears a ſmall Preſſure, and much leſs than the Body G, tho' all the Sand were contained in a Veſſel equal to the whole Circumference of the aforeſaid Bank; and therefore that a Man that were at G under this heavy Sand-Bank, would not be able to ſtir from thence, whereas if he were at K, he could raiſe himſelf with little Trouble.

But now if inſtead of this Sand there were a Veſſel of liquid Matter in the very ſaid Form, the Body K would be preſſed with equal Gravity as G, in Conſequence of the *Law of Preſſure.* From whence it is manifeſt, that if we rightly diſtinguiſh the Action of Solid from that of Fluid Bodies, this Objection will fall itſelf.

SECT. LXII. *Convictions from the foregoing Obſervations.*

AT leaſt, without inſiſting upon any farther Particulars, it will be unqueſtionable to ſuch as are verſed in the modern Natural Experiments, that without the Operation of this *Law of Preſſure, &c.* in fluid Matters, Men would be entirely deprived of the uſe of their Houſes, and greateſt Conveniences.

And this being ſo, what Reward would not a Man have deſerved that had invented a Method to hinder the ſame, or that could have preſcribed ſuch a Law to fluid Bodies? Would not every one, even an Atheiſt himſelf, think he was very much wronged, ſuppoſing he had only prevented all theſe Inconveniences after a much more imperfect manner, if inſtead of returning him the

Thanks that were ſo juſtly due to him, People ſhould look upon him as an ignorant or fooliſh Fellow.

SECT. LXIII. *Even Lead it ſelf will float upon the Water, by the Preſſure thereof upwards.*

BUT if we now turn our Eyes towards that wonderful Action of the *Law of Preſſure*, &c. namely, the *Preſſure of Fluids upwards*; there will here likewiſe be viſibly manifeſted the Glory, Power, and Goodneſs of the ſupream Director.

Now that all Liquids which have others on the ſide of them, do exert a real Force which preſſes upwards, has been ſhewn before, and may appear likewiſe from the Experiment of Mr. *Boyle*, which we ſhall repreſent here below, after a cheap and eaſie manner.

Could any Body who is unexperiencd in *Hydroſtatics* eaſily believe that a piece of Lead, which is ſo much heavier than a like quantity of Water, ſhould only by the Preſſure thereof upwards, without being ſupported by any other Matter, be kept floating and hinder'd from ſubſiding? And yet we ſee this happen, when there is no Water above the Lead, which by its Preſſure might ſink it down, and when the lateral Water is 13 or 14 times deeper than the thickneſs of the Lead.

They who deſire to make an eaſie Experiment thereof, may take a Tin Tube *d a b f*, (*Tab.* XXVI. *Fig.* 1) the lower Orifice of which, *a b*, is ſmooth and even; then taking a round piece of Lead *a b m n*, the thickneſs of which is about $\frac{1}{5}$ or $\frac{1}{4}$ of an Inch, and its Breadth *a b* ſuch, as being laid upon the Mouth of the ſaid Tin Tube *a b*, may ſtop the ſame; let there be likewiſe a little Hook *e*, fixed *e*, fixed as near as poſſible in the middle of the Lead, and a String *e k* tied to it. Then covering the Lead *a b* with a little piece of Leather, or a wet Bladder with a Hole in the middle of it, to the end that the Hook and String may paſs through, you muſt draw therewith the ſaid Lead A B N M pretty tight againſt the Mouth *a b* of the Tin Tube *a b d f*; then holding them thus together, let them down ſuddenly into the Water to the Depth *d m* (which is about thirteen or fourteen times as much as the Thickneſs of the Lead *a m*) in a large Veſſel N T C O, in which the Water is at the Height of N O; you will then find that the little String *e k*, and conſequently the piece of Lead *a b n m* being free, will not ſink down at that place, but will be ſupported by the Force of the Water preſſing upwards, and perfectly ſwim, according to the Experiments we have frequently made thereof.

Now that this happened only by the Preſſure upwards, appears from hence, That if the Lead were not let down lower in the Water than about ten or eleven times its own Thickneſs, it would preſently, upon looſing the little String *e k*, ſubſide; but being placed much deeper under the Water, we found, that both the Tube and the String itſelf being looſened, the Lead did not only not ſubſide, but even the whole *Apparatus* was lifted upwards, riſing and ſinking like a piece of Wood.

The reaſon whereof is clear enough, as well from what has been ſaid before, as from the *Law of Preſſure*, &c. for ſince the Lead is about twelve times as heavy as the like Quantity of Water when it is brought to be thirteen times deeper than its own Thickneſs *a m* below the Water N O, and the Tube being held faſt and ſtill by the Hand, as the Lead is by the String, it is plain that the part *g h* of the horizontal Plane is preſſed down by the perpendicular Column *p q h g*; now this Column being thirteen times as high at *p g* as the Lead *a m* is thick, the Water *m n*, which is under the Lead, will preſs with the ſame Force upwards; and ſince the Lead is only able to preſs upon the ſaid Water *m n* with no more than twelve of the thirteen parts, (it being but twelve times as heavy as a like Quantity of Water) it is plain enough that the ſaid Water is preſſed upwards with thirteen, and downwards with but twelve parts; ſo that the inferiour Preſſure of the Water being greater than the ſuperiour of the Lead, the ſaid Lead muſt emerge, and cannot ſubſide. From the ſaid Principles it may be proved, why Lead, being let down into the Water but nine or ten times as deep as itſelf is thick, does on the contrary immediately ſubſide, which is likewiſe always verify'd by the aforemention'd Experiment.

Of the aſtoniſhing Force wherewith this Preſſure of Fluids upwards and downwards is brought to paſs, it will not be neceſſary to ſpeak now, after what has been ſaid above in the XIXth *Contemplation.*

And from this Experiment, and from what has been ſhewed before about the ſinking of Wood, we may plainly enough conclude, that a piece of Wood, and much more the ſmalleſt Ship, would ſink down like a Stone to the bottom, if it were not kept floating by the Preſſure of the Water upwards.

SECT. LXIV. *Convictions from hence.*

CAN now an unhappy Atheiſt fancy to himſelf, that this Force of the Water, whereby a Ship is cauſed to float and ſail upon the Sea (for want of which the World would be deprived of the greateſt part of its Happineſs) is produced by Chance?

Shall we judge thoſe to be wiſe and ingenious, and to have obliged the World, who have brought Ships and all their Tackling to that Perfection in which we now ſee them? And can it be thought, that the cauſing the ſame to move round the whole Globe of the Earth, in a manner not to be comprehended by the greateſt Mathematicians, and the making it to ride upon the back of a matter fluid, unſtable, and yielding to the ſmalleſt Impreſſion, could ever be brought to paſs, but by a Being infinitely more Wiſe and Good?

And tho' the perpendicular, or downward Preſſure ſeems in ſome manner to reſult from the Weight of Fluids; yet could ever any body have ſuſpected to have found therein this Law of the upward Preſſure of Fluid Matters, had not the ſame been demonſtrated viſibly and experimentally? Is there not then a wiſe Diſpoſition requir'd here, and a directive Power extending itſelf to the ſmalleſt Particles in fluid Bodies, which ballancing them only by two equal Powers acting againſt each other after a moſt ſurpriſing and unconceivable manner, even when they appear to us in an impotent Reſt, and ſeem to be perfectly void of Action and Motion, compells them to ſtand ſtill? What can one ſee in the Water called the *Y* before *Amſterdam*, when it is not moved by any Wind, but has a Superficies as ſmooth as Glaſs, that can be compared with ſo unconceivable and violent a Force, by which whole Fleets laden with Cannon and other heavy Burdens, are hindered merely by this Preſſure upwards from ſinking down a Hair's Breadth. And can any one reflect upon what has been ſaid, and upon ſuch an infinite number of Millions of Millions of Particles of Water, all compelled to obey this Law, without diſcovering therein a Wiſdom and Power that far exceeds all human Underſtanding? In which ſo viſibly appear the great Deſigns of God in making the Seas and other Waters capable of bearing ſuch mighty Burthens, at the ſame time that they are compoſed of a matter that may be ſeparated and exhaled by the ſmalleſt Force of the Sun, or any other Warmth, and drawn up into the Air, and turned into Clouds and Vapours.

SECT. LXV. *Lateral Preſſure, and the Benefit thereof.*

Now as the Wonders of the Preſſure of Fluids upwards and downwards, are calculated to render Mankind happy, ſo likewiſe may this ſame *Law of Preſſure according to Depth* (by which the lateral Preſſure is alſo regulated) ſerve for a great Proof particularly, that without the ſame the Sea would be unnavigable for Ships, and the Earth in a great meaſure uninhabitable, ſo that many well-peopled Countries would have nothing to expect but the utmoſt Deſtruction. Let it be ſuppoſed for Inſtance (*Tab.* XXIX. *Fig.* 5.) that the Sea B C D E ſtands at the Height B C againſt the Dyke A C M N; and firſt that the Water being moved by no Winds, there lies a Ship ſtill at I F K, and at the ſmall diſtance B H from the Dyke: Now 'tis plain, that if Fluids were governed by no other Laws than ſolid Bodies, the little Water at A H F being much leſs in Quantity, and therefore in Force and Gravity, the Ship would be thruſt by the greater Quantity of Sea-Water E G F, towards the Dyke A B; according to which manner it would not be able to lie ſtill in any part of the whole Sea, without being preſſed by the heavieſt and greateſt Quantity of Water towards the ſide of the ſmalleſt and lighteſt.

We don't take any notice here of the Obliquity of ſuch Preſſures.

Now what Inconveniencies would occur from the ſailing upon the Sea and other Waters, if the ſame ſhould exert their Preſſure not according to the ſimple Laws of Depth, but like ſolid Bodies, according to their Quantity and Surface alſo?

But that which we now have chiefly in view is, what Dykes at A C M N would Men be obliged to make, if they were to be oppoſed againſt the lateral Preſſure of the whole Sea C D E B, if the Force thereof were only regulated according to the Surface and Quantity of the Water that preſſed upon the Dyke, as it happens in ſolid Bodies, had it not pleaſed the Director of all things to ſubject the Force of this lateral Preſſure ſo ſtrictly to the ſingle Height or Depth of the Water, and not to its Breadth and Quantity; inſomuch that altho' the whole Sea ſhould preſs againſt one Dyke at B C, the ſaid Dyke would bear no greater Burthen than the Preſſure of that little Water which (ſuppoſing C L to be equal to B C) could only be contained in the Space B C L, according to what we have already ſhewn above?

SECT. LXVI. *Convictions from the ſame.*

Now can any one ſee exerted ſuch a Law of ſo many Millions of ſuch exceeding ſmall Particles of which the raging Ocean is compoſed, and which have not the leaſt Knowledge of what they are doing, and yet act with ſo much Niceneſs at all Times, and upon all Occaſions; and cannot he therein diſcover an over-ruling Wiſdom and Power? The rather, ſince this Law is the only Means by which ſuch a dreadful Collection of Waters is hindered from overflowing the dry Land, whilſt the Dykes reſiſt their whole Force, ſo that neither

Men nor Beaſts are overwhelm'd in the lower Grounds; of all which one cannot think without Emotion and Horrour, when one reflects upon the Weakneſs of the ſaid Dykes, with reſpect to the unconceivable Weight and Quantity of the Water that preſſes againſt them.

If now any living Man had found out the Secret of obliging the whole Sea to ſubmit itſelf to ſuch Laws, that how vaſt ſoever it was, but a very ſmall part of it ſhould preſs upon the Dykes, would not an Atheiſt ſtand aſtoniſh'd at his Wiſdom? And if he had invented a Method, whereby not only all Waters, but likewiſe the whole Ocean of Air ſurrounding the Globe of the Earth, and all other fluid matters, even to the ſmalleſt Particle of them, could be bound and ſubjected thereto; would not an Atheiſt be again obliged to confeſs the unconceivable Extent of his Power?

CONTEMPLATION XXVII.

Of ſome CHYMICAL LAWS *of Nature.*

SECT. I. *Tranſition to other Laws.*

AFTER having contemplated thoſe Laws which have long been, and particularly of later Years are become the Objects of Mathematicians, let us now paſs on to another kind of Laws of Nature, which do not ſeem to be executed ſo much by plain Percuſſions or Strikings, as many of the firſt, but according to other Rules (we ſay *ſeem*, becauſe we acknowledge ourſelves ignorant of the manner thereof) by which Things being placed at a certain diſtance from each other, are *attracted* (or at leaſt do *move*) towards one another, without any viſible diſcovery of Percuſſion or Striking of other Parts there preſent; or elſe ſuch, as being placed in certain Circumſtances by or near other Bodies, are *driven away* or ſeparated from one another, to which Actions the Learned have annext the Terms of *Attraction* and *Repulſion*; to which Laws the Great Director has bound thoſe Bodies that obey the ſame, after a manner hitherto more wonderful than intelligible; and as the Naturaliſts have diſcovered the former Laws by Experiments, ſo the Chymiſts in a great meaſure have found out theſe, which likewiſe have lately become the Objects of Mathematical Contemplations.

SECT. II. *Experiments ſhewing the Operation of* Acids *and* Alcalies.

THE great Phœnomenon of Nature, and which has given a handle to many Diſputes and Argumentations of Chymiſts and other Philoſophers, is the famous Effects produced by *Acids* and *Alcalies*. By this laſt is underſtood every thing that ferments or boils up when mingled with *ſoure* Bodies, and afterwards is intimately united to the ſame. Thoſe who have never ſeen the Action reſulting from the Mixture of Acids and Alcalies, would be wonderfully ſupprifed thereat; and they may eaſily make the Experiment, by putting in a little beaten Crabs-Eyes, which is the Alcali, into Vinegar, which is the Acid, and they will preſently ſee the Effects thereof.

But the Motion will be much more violent, if one mixes the Filings of Iron with the Acid Spirit of *Salt-Peter* or *Aquafortis,* and attended even with a great Heat.

To ſhew this Efferveſcence in Liquids, we may take Spirit of *Sal Armoniac* mixed with melted *Pot-Aſh,* or *Salt of Tartar,* in Water, and mix it with the *Acid Spirit of Salt, Salt-Petre,* or *Vitriol,* and we ſhall preſently diſcover a ſtrong Efferveſcence between them.

SECT. III. *The aforeſaid Salts are changed and united by Efferveſcences.*

NOW how many Effects reſult from theſe Efferveſcences, has been often ſhewn experimentally by the Chymiſts.

It is a common Conſequence, that after theſe Motions both the Acids and Alcalies loſe their former Properties, or at leaſt do frequently ſeem to loſe them, ſuch as their Taſte and Sharpneſs, and being cloſely united to each other, do thereby produce a third Conſtitution entirely different from each of the former, ſuch as what the Chymiſts call a *Sal Salſum, Enixum, Muriaticum, Neutrum* or *Mixtum,* or as we call them in our Language, a *ſatiated,* a *Pickle-Salt,* or a mingled Salt, all proceeding from a Mixture of Alcaline Salts, as *Pot-Aſh,* or Volatile Salts with an Acid.

SECT. IV. *Experiments, ſhewing that* Acids *and* Alcalies *precipitate, or are ſeparated from each other.*

BESIDES this, when ſome of the ſaid Alcalies and Acids already united with each other, and, as they term it, are ſo far *ſatiated,* that they will not act any longer upon others of the ſame Kind, and adhere ſo cloſely to the former, that it would be very troubleſome to ſeparate them again without the Addition of other Matter, and in ſome Caſes even impoſſible

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TAB. XXV.

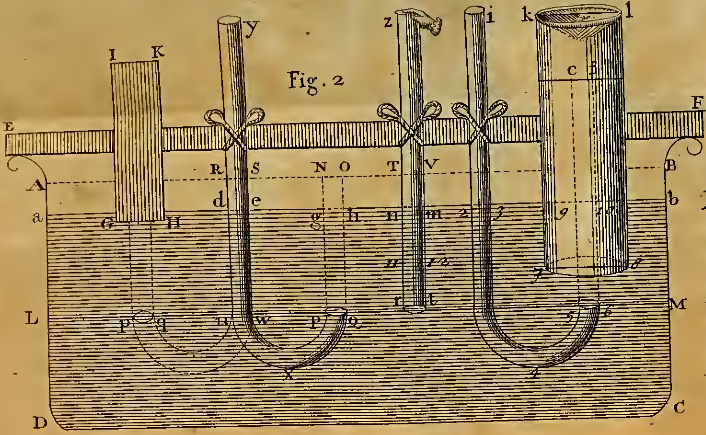
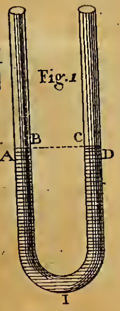


Fig. 2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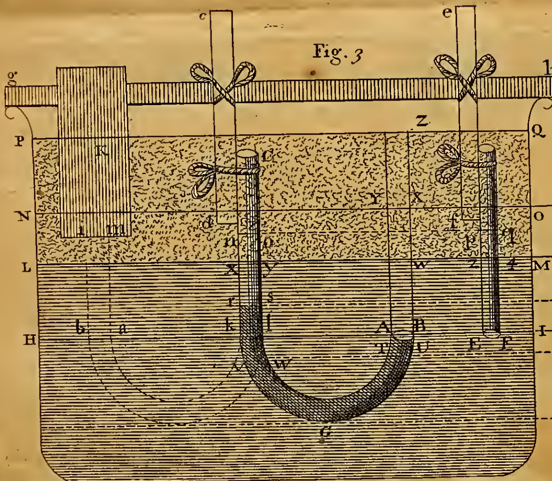
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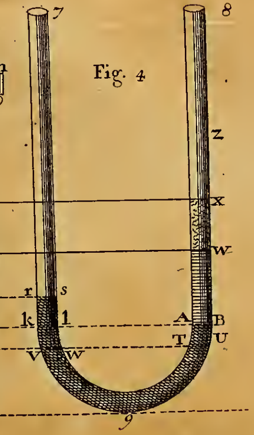
Fig. 4

TAB. XXVI.

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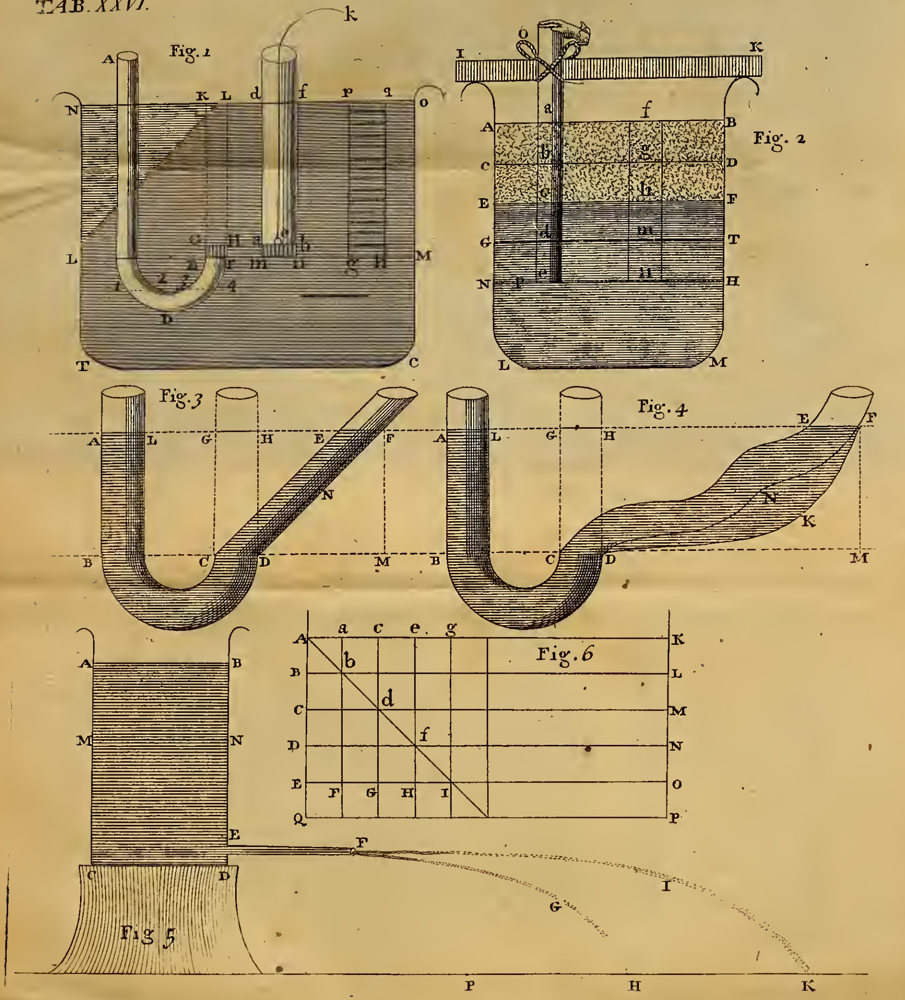

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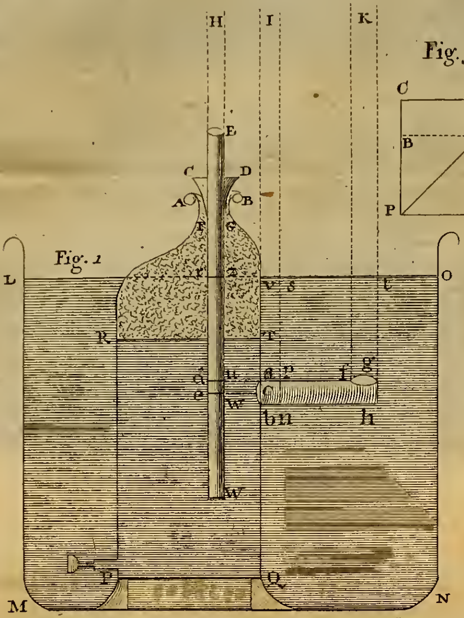
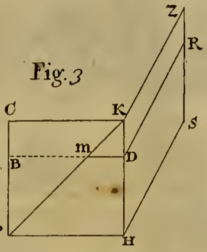
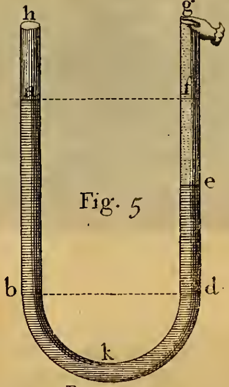
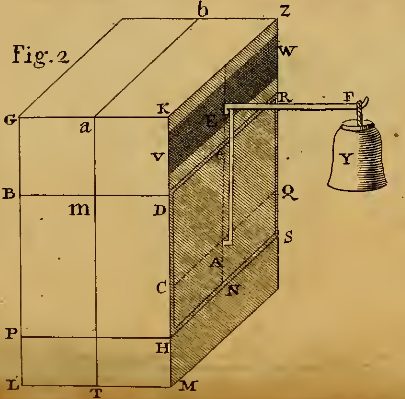
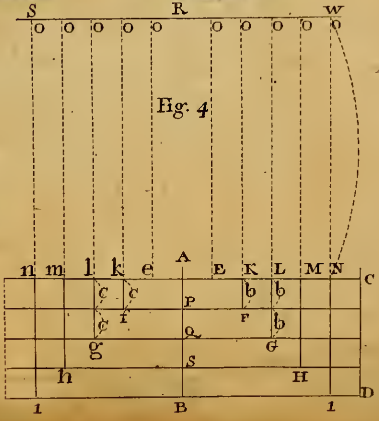
TAB. XXVII.











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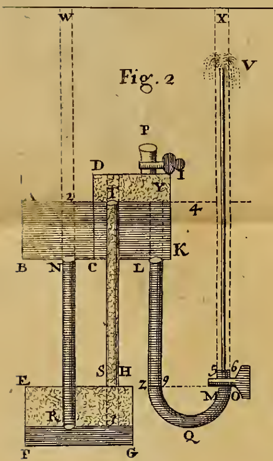
TAB. XXVIII.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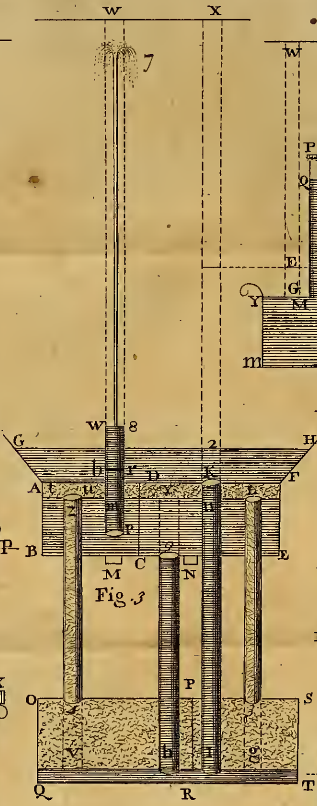
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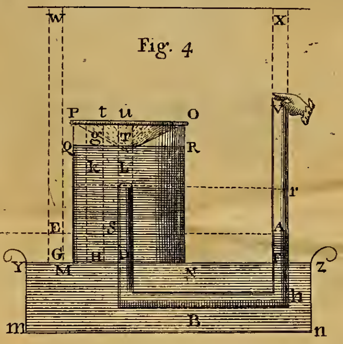
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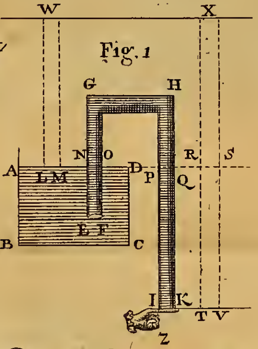
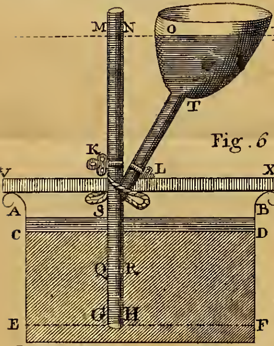


Fig. 1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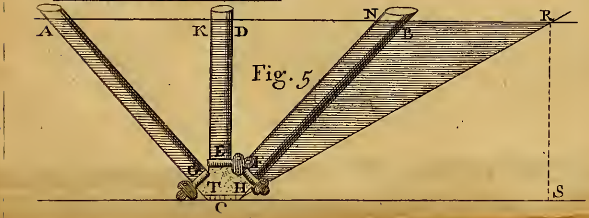
Fig. 5

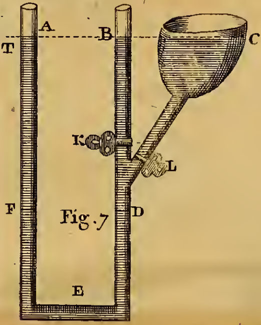
Fig. 7

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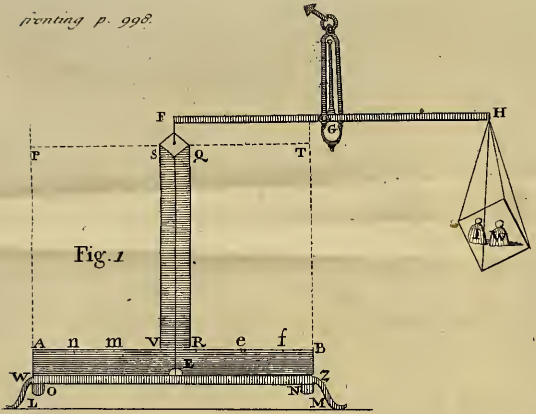

Fig. 1

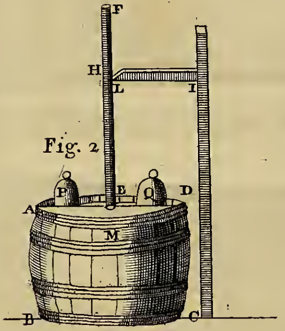

Fig. 2

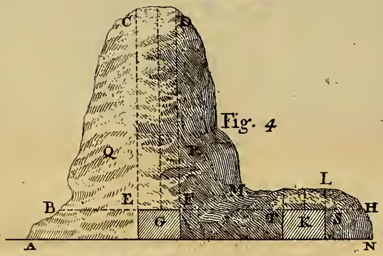

Fig. 4

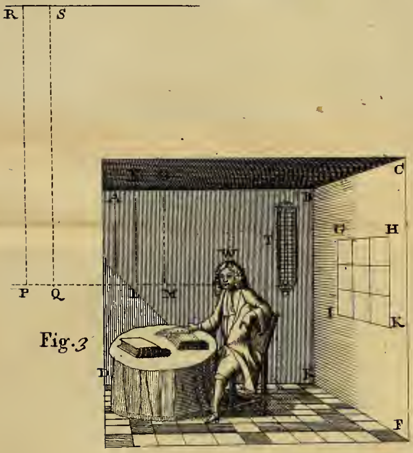

Fig. 3

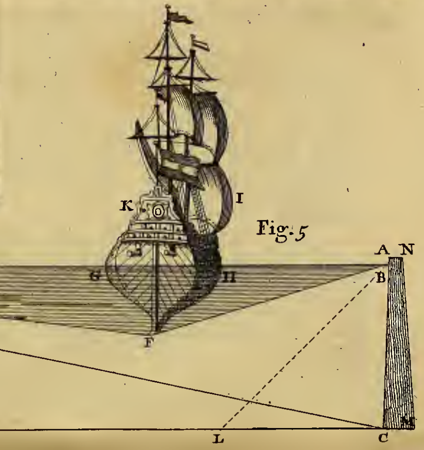

Fig. 5

poſſible to do it at all; Tryals of the Operations of theſe Salts upon one another have taught Inquirers, that there are likewiſe among thoſe Laws obſerved by the Acid and Alcaline Salts, ſome whereby this ſtrict and cloſe Union may be very eaſily, and yet as it were miraculouſly diſſolved, and each of them ſeparated from the other in ſuch a manner, as if one of them thruſt t'other Way, or at leaſt quitted its hold, without any external Cauſe that we have as yet been able to diſcover.

Thus we find, that one Acid ſeems ſtronger than another, and that how ſtrictly ſoever ſome Acids are joined with Alcalies, one need do no more in many Caſes than to put another Acid to it, whereby to oblige the firſt Acid to forſake its Alcali, and then the ſecond will unite itſelf to it. The ſame thing does likewiſe obtain in Alcalies, ſo that one of them ſhall immediately ſeparate itſelf from its Acid, and leave the latter to be join'd thereto.

Many Inſtances thereof may be met with in Chymiſtry, but we ſhall content ourſelves with quoting one of each.

Pour Spirit of Sea-Salt, which is an Acid, upon the Alcaline Salt of Tartar, they will effervesce, and unite themſelves into a third mix'd Salt, which is like the Sea-Salt: But how much Fire and Pains it will coſt to ſeparate this Acid Spirit of Salt from the Alcaline Salt of Tartar, is well known to thoſe that have made the Tryal; but if you put a little Water to it, and ſome of the Acid Spirit of Salt-Petre, the Acid of the Sea-Salt will quit its Alcali without any Trouble, and ſuffer itſelf to be drawn off by a ſmall Fire; whilſt at the ſame time the ſaid Spirit of Salt-Petre unites itſelf with the Alcali, or Salt of Tartar, and thereupon produces a new matter of Burning Salt-Petre, upon which if you pour again an Acid Spirit of Copperas with a little Water, there will be another Separation between the Acid Spirit of Salt-Petre and the ſaid Alcali; which may likewiſe be extracted from thence with a ſoft Fire from Sand; and this third Acid,or Spirit of Vitriol, will unite itſelf to the Salt of Tartar, from which there will reſult another Salt, almoſt of the ſame kind with that which is commonly called *Tartarus Vitriolatus.*

To ſhew the ſame likewiſe in the Operation of ſeveral Alcalies, pour the ſaid Spirit of Sea-Salt upon the Volatile Alcaline Salt of Animals, of Hartſhorn, of *Sal Armoniac*, and the like, diſſolved in Water, whereupon, after an Effervеſcence, they are united into a third, like *Sal Armoniac*, and the Volatile Salt will thereupon loſe a great part of its Volatility and Scent in the Mixture. Now if you add Salt of Tartar for a ſecond Alcali, it will ſeparate the firſt, and diſcover itſelf preſently by a new ſtrong Smell, and the ſecond Alcali, or Salt of Tartar, will unite itſelf with the Acid of Sea-Salt. They that have a mind to ſee ſeveral Kinds of Alcalies, the firſt of which, by the Addition of a ſecond, will ſeparate itſelf from the Acid, may be pleaſed to conſult the following *Contemplation, Sect.* VI. beſides innumerable Inſtances wherewith Chymiſtry can furniſh 'em; but we ſhall not, nor cannot here determine any thing about the Manner uſed herein by the wonderful Power of God, reckoning it ſufficient that the thing is plain enough in itſelf.

SECT. V. *Acid Salts diſperſed in many Bodies.*

IT muſt not be thought, that theſe Effervеſcences, and Actions of Acids and Alcalies, have only place in Chymical Liquors; and that we therefore go too far in honouring them with the great Name of a Law of Nature; foraſmuch as they, that is, one or other of them, are found in many Terreſtrial Bodies, and that a great deal of that Matter of which many Bodies are compoſed, may be reduced to Acids or Alcalies.

To ſhew this in the Acid:

In *Animals* all the Milk and *Serum*, or Whey, is Acid; not to enumerate any other Juices here, particularly thoſe Acid Humours which oftentimes occur in many unhealthy Creatures; or, as ſome maintain, are always found in the Stomach of healthy ones.

We likewiſe meet with Acids in *Minerals*, as in Sulphur, Copperas, Allum, Salt-Petre, Sea and Rock-Salt, in Antimony and others.

In *Plants* we likewiſe find ſome that yield an Acid Spirit by Diſtillation; beſides all thoſe Fruits which are ſoure becauſe they are not ripe, we meet with an infinite number, which after they are come to their full Ripeneſs, do retain an entire Acid or ſouriſh Taſte; ſuch as Currants, Oranges and Limons, many Apples and Pears, and the like. Beſides that almoſt all Liquors proceeding from Plants, or other things, by way of Fermentation, ſuch as Beers, Wines, and the like, will turn to an Acid or Vinegar.

The *Air* itſelf ſeems to be impregnated with ſoure Particles, ſince it will corrode and cauſe Iron to ruſt.

There are likewiſe *Medicinal Springs* that yield ſouriſh Waters, found in many Countries; ſee *Varenius*'s *Geography*, *Part. abs Cap.* 17. *Sect.* 6. of which he makes the number in *Germany* alone to amount to about 1000; ſo that from hence may be inferred the Quantity of Acids diſperſed throughout the whole Earth.

SECT. VI. *Alcaline Salts likewiſe diſperſed in many Bodies.*

ONE may ſay the ſame thing of the Alcaline Salts alſo.

From all the Parts in a manner of *Animals*, there are Alcaline Volatile Salts extracted in great Quantities; to ſay nothing here of other Alcalies, which cannot properly be named Salts, ſuch as Crabs-Eyes, Egg-Shells, the burnt Shells of Oyſters and Muſcles, Hartſhorn and Bones.

Plants, when putrify'd or rotten, do likewiſe yield Alcaline Volatile Salts. The Smoak of burnt Wood makes a Soot, which does alſo afford an Alcaline Volatile Salt; and the Leaves of ſome Plants, ſuch as the Palm, yield an Alcaline Spirit by Diſtillation. The Chymiſts do moreover extract from moſt Plants by Burning, a fix'd and lixiviate Salt, which is likewiſe Alcaline, and of which the Aſhes themſelves will efferveſce with Acids.

All ſort of *Coral* is Alcaline, ſo are many *Minerals*, and will ferment with Acids; as alſo all *Metals*, Gold, Silver, Copper, Iron, Tin, Lead, Quickſilver, Antimony, Marcaſites, the *Lapis Calaminaris*, Chalk, *&c.* Even a good fertile Earth will efferveſce with Spirit of Salt-Petre. There are likewiſe ſome of the Mountain or Rock-Salts of the ſame Nature. Accordingly we are informed, that in the Repoſitory of the *Royal Society* of *England*, there is preſerved a Salt brought from the Rocky Places of the Iſland of *Teneriff*, the Properties of which are entirely Alcaline; and in how many Mineral Waters a like Alcaline Salt is found, may be ſeen in the Hiſtory of the *Academie Royale des Sciences*, &c. *An.* 1702, *p.* 57 and 58, and 1708, *p.* 73 and

74; where an Inquiry being made into the Waters of *Bourbon*, *Lancy*, *Bourbon d'Archambaut*, *Bourboule*, *Mont d'Or*, *Chaudes*, *Aigues*, *Evaux*, *Neris* and *Vechil*, are all found to yield a natural Alcaline Salt: So that it likewiſe appears from hence, that Alcalies as well as Acids may be met with in great Quantities in many Bodies.

SECT. VII. *Convictions from the foregoing Obſervations.*

FROM what has been ſaid, and from a farther Inquiry into Nature, one might produce a vaſt number of Experiments and Proofs, capable of convincing a judicious Reader, that there is an infinite number of Particles in the World, each of which are conſtantly moved according to particular Laws, which in ſome Circumſtances are at reſt, and of which others being brought to a certain determinate diſtance, as the Acids and Alcalies, begin a regular Motion, being ſometimes *attracted*, and at other times *repelled* from each other. Do not the Parts of Diamonds adhere together very cloſely, tho' they have great Orifices or Pores in them, and therefore touch one another with little Superficies, as appears from their Tranſparency? Do not we ſee in Fermentations ſome Particles which were at firſt ſtill and at reſt, and afterwards begin to move among one another, in which, always following certain Laws, they one while ſeparate, and then again unite with each other? But they who deſire to ſee a brief Collection thereof at one view, may conſult Sir *Iſaac Newton's Optics, in the Queries at the End*, and moſt of the Chymiſts; and from thence extract what they think may ſerve for a Proof ſtrong enough of what has been ſaid above.

But to ſuch as are not ſo well experienced in Chymiſtry, to give a more familiar Inſtance from whence they may ſafely infer the foregoing Propoſitions, and juſtly conclude likewiſe that there is a God, who has not only Created all theſe things, but does alſo Govern them by his Providence according to wiſe Laws; let an Atheiſt, how great a Philoſopher ſoever he be, reflect with himſelf, and conſider, *Firſt*, this Univerſe, as conſiſting of an infinite Multitude of Hundreds of Thouſands of Millions of Particles, which, according to the preceding Experiments, cannot be deny'd; *Secondly*, let him repreſent to himſelf all theſe Particles as being at reſt and unmoved; which he may eaſily do, becauſe Motion is not a neceſſary Conſequence of their Exiſtence: If now he contemplates this unconceivably great Heap of Matter, can he think it credible, firſt, That from thence are produced ſo many determinate, and ſuch exceeding ſmall *Stamina*, or Original Seeds, and from them again ſo many glorious Machines, as are the Bodies of Men and Beaſts, Fiſhes and Birds? Such wonderful Structures of Plants and Herbs, diviſible into ſuch numerous Claſſes? So many agreeable Liquors which Men extract from the ſame, making uſe therein of thoſe Laws, according to which the Juice of the Grape, for Inſtance, and others are wont ſo uniformly and conſtantly to operate? Finally, that great and amazing Machine the World itſelf, with that Order and Symetry, by which one part thereof renders ſo many Services to the other, whilſt not one ſingle Particle thereof can aſſume any kind of Figure or Motion, but according to certain Laws preſcribed to it, by and ſubſervient to the great Deſigns of its Creator; nor can it ſeparate itſelf from one, nor adhere to another Body, but in Subordination to the ſame Laws.

SECT.

SECT. VIII. *The Preſervation of Things proves a God.*

We muſt not think that nothing but theſe Laws, and the infinite Wiſdom by which they have been contrived, has place in the great and regular Structure of the World; for the preſerving and continuing of all things in the State and Condition in which they were firſt created, has likewiſe a Share in proving a God.

Would we ſee a Proof thereof, how the great Director, from a Collection of an inexpreſſible number of Particles entirely differing from each other, and which ſeems to us to be jumbled together in the utmoſt Confuſion, cauſes only ſome determinate ones, and ſuch as are ſubſervient to his high Deſigns, to approach towards each other, and to unite among themſelves and with other Bodies proper to preſerve, nouriſh and increaſe them according to the Laws impreſſed therein by his infinite Providence; let us recollect what has been ſaid above upon this Occaſion.

Is not the Air a Mixture, yea, a very *Chaos*, conſiſting of Hundreds of Thouſands of Millions of different Particles? How many things conſumed by Fire, and diſſolved by Corruption, do mingle their Effluvia, Steems, or Vapours, with the Air? How many Men and Beaſts do perſpire therein; yea, according to Mr. *Boyle*, almoſt all Bodies, not excepting Ice and Snow themſelves, become lighter by Perſpiration, and tranſmit their exhaled Particles into the Air? How many ſweet-ſcented Flowers, how many Spices and other things impregnate the ſame with fragrant Particles, inſomuch that the Perfumes of them have been ſmelt ſome Leagues diſtance from the Iſlands where they grow, according to the Relations of thoſe who have experienced the ſame? Every body knows, that in Cellars where there are fermenting Wines, the Air is full of their Vapours and Spirits; which holds true likewiſe in all other fermenting Matters. How many watry Vapours from Seas, Rivers, Lakes, Marſhes; how many ſulphureous and other corroſive and poiſonous Particles aſcending from burning Mountains, mingle themſelves with the Air? Iron which, in all Parts of the World almoſt, being expoſed to the naked Air, becomes ruſty, furniſhes us with unqueſtionable Proofs of the Acidity thereof. With all theſe there is mingled an unconceivable quantity of Rays of Light, derived from the Sun and other Heavenly Bodies; and how much Fire is elevated and retained there, appears by Lightning and other ignite Meteors. Add to all this the proper Particles of which the Air itſelf is compoſed, and let an Atheiſt tell us, where he can find ſuch another confuſed Heap.

Let him farther conſider the Earth, and obſerve of what a mighty Variety of Kinds and Parts it conſiſts. Water is turned to Earth, as we have ſhewn before; poiſonous and wholſome Herbs, Shrubs and Trees, all the Bodies of Fiſhes, Beaſts, and Men do likewiſe become Earth. In a word, whatever proceeds from the Earth, is by Corruption or otherwiſe changed into the ſame. Let an Atheiſt reflect again, how many Thouſands of Kinds of different Compoſitions all this Heap of Matter might produce, every one of which might likewiſe be exceedingly different from all that we now ſee proceeding from the Earth.

In the Water we may obſerve the ſame; How many Plants and Fiſhes are corrupted therein? What a great diverſity of Dews fall upon it, drawing Particles of the Air along with them? How many Salts are diſſolved therein? How many ſubterraneous Fires fill them with the Matter that burſts out of their Caverns? Water waſhes all Filthineſs off, and how many Particles does it borrow from the Things in and upon which it has ſtood any while? Coffee and Tea, all ſort of brewed Liquors, the Off-ſcourings of Apothecaries Shops and Kitchens; to ſay nothing of Minerals, of hot, bitter, and poiſonous Liquors, nor yet of ſalt Sea-Waters; all theſe things, I ſay, furniſh us with Proofs that are obvious to every one.

To take no notice neither of Fire, which does in a manner unite all things with itſelf; let the Atheiſt repreſent to himſelf all theſe confuſed Collections of Water, Earth and Air; and in caſe there were no Laws by which each kind were particularly governed, and purſuant to which theſe Particles join themſelves with ſome Bodies, and again refuſe to come near others, could he himſelf, or any body elſe think it poſſible, that from all this Chaos, there ſhould not once, but even frequently, and from ſome of them every Year, be produced anew ſo many different things of particular Properties, and that it would have ſo happened as long as the World has laſted?

To give an Inſtance in one kind of thing only. Let any body ſow different ſorts of Seeds by one another in the ſame Earth; they will ſtand in the ſame Air, they will be moiſtened with the ſame Water, warmed with the ſame Sun, and acquire from them all, according to what has been ſhewn above, an infinite number of different Particles round about them. Now let ſuch, who to their own Misfortune deny a Divine Providence, tell us how this can poſſibly happen, were it not that certain Laws obtained in all theſe numerous kinds of Parts, and which are the Cauſe that every Particle neceſſary to the Growth of every individual Seed, does unite itſelf therewith, and to no other of different Properties, and how every Seed can always produce its own Plant of the ſame Kind and Virtue every Year without once failing? And why, when there are ſuch poiſonous Herbs as *Aconitum*, *Hemlock*, and the like, ſcattered and mingled in the ſame Earth with Wheat, Rye, Barley, and other Grain ſo uſeful to Mankind, there are joined only to the firſt, fatal and deadly Particles, and to the latter, only wholſome ones? And why an Apple-Tree never bears Pears, or a Vine, Cherries?

SECT. IX. *All kinds of Philoſophy do, or muſt, acknowledge Laws.*

LET the moſt experienc'd Philoſophers be called upon, and let them tell us themſelves, if they will declare their Sentiments impartially, whether, without acknowledging theſe Laws and a directing Providence, they can make theſe and ſuch like Phœnomena (for there are many ſuch in the World) the neceſſary Conſequences of the Hypotheſes upon which they found the Science of Nature.

Some have thought upon a Magnetical, and other kind of Attractions; but theſe lay down one ſort of Laws.

Others ſuppoſe a certain kind of *Ferment*, as the Chymiſts ſtile it, in the *Stamina*, or Principles of Seeds, of which there can be no other Notion formed, than that they are Parts figured after a particular Manner, and moved according to certain particular Laws, and which unite themſelves with ſome Bodies, and ſeparate from others.

Finally, ſince both theſe Hypotheſes have been rejected of later Years, thoſe that have philoſophized more rationally, have laid down, that there are Pores or Orifices in Seeds of certain Figures, through which only are admitted Particles of the like Figure; which, according to the Opinion of others, who will not own a Direction, becauſe that leads them to a GOD, may come to paſs by Chance or Neceſſity, ſince there ſeems to be nothing more requiſite thereto, than that theſe Pores ſhould be diſpoſed to receive thoſe little Particles as ſoon as they are put into Motion. But according to this Hypotheſis there might, *firſt*, not only all kind of Particles be admitted into the Pores of the Seed, provided they were but ſmall enough; but likewiſe, *ſecondly*, there would hardly be one Seed capable of growing, and but very few Particles enter into the ſame, ſave only round ones, if nothing but meer Chance obtained therein, as Dr. *Pitcairn* has expreſly and mathematically demonſtrated in his *Diſſertations*; ſince the ſame kind of Particles muſt always preſent themſelves before the ſame Pores, and exactly after the ſame manner, if they would gain Admittance. But let us ſhew this by a more familiar Inſtance: Suppoſe any one ſhould undertake to throw a Die through a ſquare Hole, through which it could but juſt paſs; muſt he not ſtipulate, in order to have an equal Chance of winning or loſing, to repeat his Throw a great many times? So that if ſomething like this ſhould be the true Cauſe of growing of Plants, and all the Particles of the Figure of a Die ſhould always paſs through the ſquare Pores in a Seed; there muſt at leaſt in this Caſe, as much as in any other, be a Rule or Law, according to which each Die muſt be diſpoſed when it comes againſt the Orifice or Hole.

We do not here diſpute, whether any thing of all this, or ſomewhat elſe, be the real Cauſe, that among ſo many Thouſands of various Particles, thoſe only approach to, or are attracted by each Seed, which are moſt proper to compoſe the particular Plant in its kind; but our Deſign was only to ſhew, that without acknowledging a Divine Direction, whereby all things are moved according to the requiſite Laws, whereby ſome things are made to approach, and others to recede, and which are extended to every one of theſe unconceivably ſmall Atoms, no other Hypotheſis has hitherto been offer'd, whereby the Growth of Plants and many other Things could have been reſolved. In ſhort, to obviate all the Evaſions of Atheiſts, let us recollect from what has been ſaid above, that among the Thouſands of kinds of Animals and Plants, there is not one only to be found which was not at firſt formed of an exceeding ſmall *Stamen*, containing all the Parts thereof in Miniature, and from whence, by Expanſion or Unfolding, and by covering or cloathing with adventitious, particular and determinate Matter, all Plants, all Men, Beaſts, Fiſhes, Fowls, and every other living Creature are produced, as is well known by the general Experience of thoſe that uſe Microſcopes. Let then the Atheiſt or Sceptic think with himſelf, whether he can reconcile all this to a mere and accidental Concourſe of ignorant things; and theſe curious little Forms and Figures, in which all that is neceſſary to ſo many wonderful Purpoſes in great Bodies, are compris'd in a much ſmaller Quantity than a Grain of Sand: I ſay, let him make all theſe things agree with thoſe neceſſary Laws, that operate without any wiſe Direction or View. After ſo many illuſtrious experimental Proofs of the Wiſdom of an adorable Creator, no reaſonable Perſon can require any more; eſpecially if it be true (as ſome Great Men think it very probable) that in all theſe *Stamens*, how ſmall ſoever they may be, thoſe of all others that are to be produced to the end of Ages, are actually to be found in their determinate Figures.

SECT. X. *The Opinions of ſome Philoſophers about Fertility.*

I DON'T know, whether it may not be thought proper by ſome to add to all this, one Notion more, which appears very plauſible to many, but yet ſeems to require a farther Examination and Trial before it be entirely admitted for certain: But ſince the ſame has been entertained by ſeveral Great Men, and ſeems to have ſome Analogy with the Chymical Operations and Action of the Parts of Matter upon one another, and eſpecially ſince the thing carries along with it a great Proof of God's Providence; it may perhaps be of uſe, if we here ſubjoin a few Obſervations that may ſet the ſame in ſome kind of light; and, it may be, alſo excite thereby ſome of the Learned to look farther into a thing that is at leaſt worth double their Pains.

It conſiſts in the Inquiry of what may properly be the Means which the Gracious Preſerver of all things makes uſe of to render the Earth fertile, and to cauſe Plants to grow powerfully therein.

Now that which may be experimentally pronounced upon this matter, according to the Opinions of many Naturaliſts, is, that the Nitre of the Air is the Cauſe thereof; to which perhaps one may add, that ſince Nitre, or Salt-Petre, is alone and of itſelf an unactive Matter, there muſt ſomething elſe concur to put it into Motion; much after the ſame manner as it happens to the Acids and Alcalies, which, when ſeparate, are at reſt, but being put together will effervefce and boil up with each other. The ſame happens by the Mixture of Salt-Petre and Brimſtone in Gunpowder.

SECT. XI. *The Air ſeems to abound with Salt-Petre; ſeven Experiments ſhewing the Probability thereof.*

NOW to prove, if not with entire Certainty, yet with great appearance of Truth, that either Salt-Petre is in the Air, or at leaſt ſome other Matter, which being much of the ſame Nature, meets ſometimes with ſomething elſe in the Earth, whereby between them real Salt-Petre is produced, appears from the following Experiments.

I. That the Earth may be mixed with ſuch Matters upon which the Air will operate; ſuch as the Filings of Iron, the Urine, Dung and Blood of Animals, lixiviated Chalk and Aſhes, *&c.* and that from ſuch Mixtures, after they have been expoſed for ſeveral Months to the action of the naked Air, a remarkable quantity of Salt-Petre may be extracted.

But foraſmuch as great and learned Men ſeem to differ about this Aërial Salt-Petre, I thought fit, for greater certainty, to make this Experiment, and found by the Event, that ſuch an Earth after being managed properly, yielded in a Months time about three Pound of very good raw Salt-Petre. This has been touched upon before, ſo that what is here ſaid, may be the more ſafely depended on, and the rather, if we add what ſeveral have affirmed to be experimentally true, namely, that the Earth from which Salt-Petre has been once extracted, will after a while be again impregnated by the Air with the ſame.

II. Since every Body may find, that by letting Blood run out of a Vein upon Water in which Salt-Petre is diſſolved, the black or dark Colour thereof, will be immediately turned into a bright Red; and the Serum or Whey of the Blood become as tranſparent as clear Water, tho' it retains its Nutritious, or at leaſt ſolid Parts; which by dropping a little Spirit of Salt-Petre upon it, may likewiſe be ſeparated therefrom; yea it is known that black Venous Blood being expoſed in a Veſſel or Porringer, is often red at the Place where the Air touches it; and that even upon taking off the upper red Part, the Black which was under will likewiſe aſſume a bright red Colour: I ſhall not here diſpute, whether the Air is mingled with the Blood in the Lungs, becauſe this is doubted by ſome Philoſophers; but however it is plain from theſe two Tryals, that Salt-Petre and Air do act uniformly upon the Blood; and therefore it is in ſome manner probable, that the Air is impregnated with Salt-Petre.

III. It is known to the Naturaliſts, that a great deal of Salt-Petre may be made from Blood (See *de Stair de Nitro*) if now it be true, that in Breathing, the Air is continually mingled with our Blood, one would be apt to imagine, that it leaves a great deal of its nitrous Quality therein, which may afterwards be extracted.

IV. Since refined Salt-Petre being held in a warm Hand, will ſnap and break, which perhaps might be occaſioned by the Air that was in it; I took a Piece of Salt-Petre and threw it into a bright Lie, in which there is never any Air; then putting it into the Air-Pump, I obſerved a great Stream of Air-Bubbles coming out of the Salt-Petre, and aſcending thro' the Lie.

Now whether from this Experiment it may be concluded, that the Parts of Air and Salt-Petre are eaſily united and adhere cloſe together, becauſe the Salt-Petre has ſo much Air in it, tho' Chryſtalized in Water, and reduced to little Tubes, I leave to the Judgment of others: It might however in ſome manner leſſen the Difficulty ſome People make, as if Salt-Petre were too heavy, and not volatile enough to keep itſelf up in the Air.

V. This ſeems however to be entirely removed thereby; foraſmuch as the Obſervations made by the new Burning-Glaſſes ſhew, that Salt-Petre held in their Focus, entirely evaporates, and ſo mingles itſelf with the Air *Hiſt. de l' Acad.* &c. *1699*, p. 114.

VI. All Metals, ſuch as Silver, Iron, Copper, Lead, which are diſſolved by the Spirit of Salt-Petre, eſpecially thoſe upon which it acts with the greateſt Force, as it does upon Iron, ſeem to ruſt in the Air; only Gold, which a ſimple Spirit of Salt-Petre can't touch, is not ſo much expoſed thereto: All which gives a handle to a Conjecture, that if there be not Salt-Petre itſelf, there is at leaſt ſome Matter of the like Nature in the Air.

VII. A yet farther Proof that there is ſomething Nitrous in the Air, ſeems to reſult from the pains in the Head, faintneſs and diſpoſitions to Vomit, which often appear in ſome Women when they are in cloſe Rooms, where a great many People and Stoves are. To be ſatisfy'd of this Conſequence, the Reader may be pleaſed to recollect what we have ſhewn above in the VIIth *Contemplation*, namely, that Flame and human Reſpiration are maintain'd by the ſame kind of Air-Particles; for which reaſon, the Air ſhut up in a Room where a great many Stoves are burning

ing, and a great many People breathing, muſt be very much diveſted of thoſe Parts, and be the occaſion that ſome weak Women are diſorder'd thereby. Now that theſe Parts are properly Nitre or Salt-Petre, which being render'd by the warmth of the Fire and Breathing, unfit to diſcharge its Functions, ſeems to appear from hence, that Women thus diſorder'd, cannot recover themſelves by any better Means that I know of, eſpecially when the freſh Air won't do, than by the uſe of a Nitrous Salt diſſolved in Water, of which I have ſeen many Experiments, either by putting a little Salt-Petre or *Sal Prunelle* in their Mouths, and letting it diſſolve gently, and ſwallow it down.

SECT. XII. *Salt-Petre ſeems to come out of the* North; *proved by three Experiments.*

SINCE now the firſt of the Experiments ſeems to prove, and the other to make it very probable, that the Air has either Salt-Petre in it, or ſomething of a nitrous Quality; it will appear in ſome manner from the following Experiments, that the ſame, at leaſt on our ſide of the Equinoctial Line, proceeds chiefly from the *North.*

I. Not to mention that the Air is cold to a great Degree in the *Northern* Parts of the World, (as for the *South* Pole, we take no notice of it now) nor that Salt-Petre does after a particular manner produce ſenſible Coldneſs, as we ſee by putting of Bottles of Wine in Summer-time in Water, and throwing a good quantity of Salt-Petre into it, which chills it ſo much, that ſome have thought that one might freeze Water thereby, but that I ſhall not determine: From hence it may be conſider'd, whether that Air which makes ſo many Mountains of Ice in the frigid *Zone*, and keeps them always undiſſolved, muſt not greatly abound with Salt-Petre.

II. To render this the more probable, we ſhall add what the Learned *Hambergerus* relates from the *Ephem. Barom.* of Mr. *Bernard Ramazzini*; that Gentleman ſays, that the Excreſcence of Salt-Petre from old Walls made of Mortar and Stone, does moſtly appear in Winter, and when the Northerly Winds blow; and that thoſe who make it their Buſineſs to gather Salt-Petre, do at that time particularly ſweep the Walls; and that they get more of that Matter from Walls that ſtand to the *North* than to the *South*; which ſeems to prove plainly enough, that beſides the general Impregnation of the Air with Salt-Petre, the Northern Air does moſtly abound therewith, and that it is frequently brought from thoſe Parts to us.

III. Now whether it may be inferr'd, that upon account of nitrous Salt, the Northerly Winds make the Air heavier, and that upon the turning of the Wind to that Corner, the *Mercury* does often riſe in the *Barometer*, as many who have writ upon this Matter affirm, I ſhall not here inquire after.

Now whether the Air be render'd heavier by the Northerly Winds (which bring along with them from the cold Regions, a thick and compos'd Air towards the *South*, as appears from the *Thermometers*, in which we may obſerve, that Cold compreſſes the Air, and as appears likewiſe by the Refraction of Light, which is affirmed to be greater in the *North*) or whether ſuch Gravity of the Air proceeds from the Salt-Petre wherewith it is impregnated, or for other Reaſons: They who uſe *Barometers* know very well, that the heavier the Air is, and the higher the Quick-Silver riſes, the leſs rainy and the more dry Weather may be expected. See the *Act. Lipſ. 1696.* p. 213. from whence therefore, beſides other Circumſtances that may be peculiar to the Country of the *Jews*, the Reaſon in general may be aſſigned of that Expreſſion in *Solomon*'s Proverbs, *Chap.* xxv. *ver.* 23. *The* North *Wind driveth away Rain*, ſince by the greater Weight of the Air, the watry Vapours remain floating therein, and cannot deſcend in Rain.

SECT. XIII. *Salt-Petre becomes active by thoſe Particles in it that are Sulphureous, ſhewn by Experiments.*

BUT ſince Salt-Petre ſeems to be very unactive in its own Nature, inſomuch as when put into a Melting-pot over the Fire, it does not exert the leaſt active Faculty, even with great Heat; it may be neceſſary to examine a little more cloſely, what it is that renders it Active (as Acids and Alcalies working upon each other) and how it comes to produce ſuch Wonders.

Now the Bodies which are more peculiarly proper to produce ſuch an Effect are all ſuch as come under the Denomination of *Sulphur* among the Chymiſts; to which belongs common Sulphur itſelf in the firſt Place, and every Thing elſe that has Sulphur in it; ſuch as Antimony, Turf, and Wood-Coal; and in general, all that has Fat or Oyl in it, ſuch as Tartar and the like.

Thus we ſee that Sulphur or ſulphureous Bodies, thrown into melted and glowing Salt-Petre, or elſe being mingled cold with the ſame, and ſet on Fire, are put into violent Motions, and the Mixture often turned into a ſudden and conſuming Flame: So likewiſe we find that Tartar mingled with a like quantity of Salt-Petre, will be kindled with the ſmalleſt Fire, and burn ſo long, till the Oleaginous and other parts of the Tartar are evaporated; after which there will remain a white Alcaline Salt, which is therefore called *Salt of Tartar.* After the ſame manner we ſee diſſolved Salt-Petre mixed with beaten Charcoal, or Turf char'd and thrown into the Fire, become active, and caſt out Flames; where being continued till no more Flame is perceived, the Chymiſts make of it an Alcaline Salt, which they call the *fixt Salt of Nitre:* But whether it may not more juſtly be termed the *fixt Salt of Coals*, for the ſame Reaſon as t'other is called the Salt of Tartar, I leave to the Learned: At leaſt, how very active Salt-Petre is render'd by Sulphur and Coals, Gunpowder furniſhes us with a well-known, or rather with a wonderful and terrible Inſtance.

It muſt not be thought that theſe Matters cannot be kept up in the Air, as not being fine and ſmall enough, becauſe we have ſhewn before, that beſides a great many other different Particles, there are likewiſe thoſe of Sulphur found in the Air. Thus we ſee, that in the *Mediterranean*, and other Parts of the World that are more Southern than we, there is very great and frequent Thunder and Lightning, of which in *Greenland* (as I have been informed by one that has been often there) and here with us in Winter, very little is obſerved. Now that this is occaſion'd becauſe the Air abounds with more Sulphur in the former Regions than in the latter, (whereas in *Greenland* there ſeems to be more of Salt-Petre only, which paſſing from the Northern to the Southern Parts, produces theſe Effects in Conjunction with the ſulphureous Air) is allowed by many as a very probable Thing.

It has been likewiſe ſhewn above, that the Rays of the Sun operate upon Salt-Petre, and render the ſame Volatile; for, that thoſe Rays are Corporeal, and do likewiſe even bring along with them a Matter that gravitates, appears from the Experiment of Mr. *Homberg* about the *Regulus*, of Iſing-Glaſs, as the Chymiſts call it. See the XXIVth *Contemplation.*

I know not whether I may not here add, that in the Year 1711, having gathered ſome Dew about the latter end of *May*, and kept it a while in a great Glaſs Veſſel, I caus'd the ſame to evaporate, in order to try whether there were not Salt-Petre in it, as ſome affirm; but found no Salt at that time, but only a little reddiſh Matter pretty near the Colour of the *Scoriæ*, of *Regulus Antimonii*; which being ſprinkled upon a glowing Coal, would not burn as Salt-Petre is wont to do; but when thrown into an earthen Veſſel, in which there was glowing Salt-Petre, it flamed viſibly, but however pretty faintly in compariſon of common Sulphur.

I cannot here determine exactly of what Nature that Matter was, there being too little of it to bear a further Examination; but however, I judge it to be of a ſulphureous Nature, by its flaſhing with melted Salt-Petre; at leaſt it was plain enough that Salt-Petre acted upon this, and this upon Salt-Petre.

It likewiſe ſeemed as if we might conclude from thence, the Operation of the Solar Matter brought to us by the South-Winds upon the Aërial Salt Petre, ſince we find that a glowing Coal of Turf being placed in a hot Sun-ſhine (out of the Wind which would otherwiſe blow it up) is extinguiſhed, and ceaſes to burn, juſt as if it were put into a Quenching-Pot. The Reaſon of which ſeems to be, that the Salt-Petre of the

Air, which is otherwiſe the principal cauſe of our Turfs burning, is render'd unfit by the Action of this Matter, which proceeds from the Sun, to continue the Fire of this Turf-Coal as well as before. Now that this is true, and that Salt-Petre is a great cauſe of the burning of our Fires, appears from hence; becauſe, that in the ſtrong Froſts of Winter, when the ſharp Northerly Winds reign, which have been proved before to be impregnated with a great deal of Salt-Petre, our Turf-Fire burns much brighter, and is much ſooner conſumed (as Coals are upon which one throws Salt Petre) than in Summer, when the Air has not ſo much pure Salt-Petre in it.

SECT. XIV. *Salt-Petre in Conjunction with the Rays of the Sun, does likewiſe render the Earth fruitful, ſhewn by an Experiment.*

THUS we find alſo, that the Action of Salt-Petre, and the Rays of the Sun, do contribute very much to Fertility. Not to relate here, for a Proof, Mr. *Homberg*'s Experiment in the *Tranſactions* of the *French Academy* 1699, p. 75, 76, which ſhews the ſame of Salt-Petre when diluted in Water, and poured upon Earth: One may likewiſe make another tryal, by ſteeping Grain or Seeds for ſome Hours in two Pints and half, for Inſtance, of Water, in which an Ounce of the beſt Pipe Salt-Petre has been diſſolved, and ſo proportionably; and it will be found that theſe Seeds will be much more fruitful than any other that have not thus been infuſed in Water unpregnated with Salt-Petre. I ſaw the Experiment thereof in the Year 1711, when ſome *French-Beans* that had been ſteep'd were obſerv'd to grow a third Part higher than others; and have treated ſome Purſlain-Seeds in the ſame manner, that it grew ſo large, and ſo ſtrong, that a Learned Gentleman, and one that was well verſed in Plants, could not forbear asking what it was, and ſaid, he had never ſeen ſuch Purſlain in his Life.

This Property of Salt-Petre was likewiſe known to thoſe of the Ancients that have writ upon Agriculture: But to ſhew farther that which was propoſed, namely, that not only Salt-Petre, but that which likewiſe proceeds from the Operation of the Solar Matter thereupon (allow me ſo to name either the Sun-Beams themſelves, or that which they bring along with them) does render the Earth fruitful: It will be ſufficient in the firſt Place, to conſider how much the Sun contributes to the growth of Plants, this being unknown to no Body; and it will give ſome Light to the Matter to mention here, that which happen'd to me about the latter end of *May*, in the Year 1712; for having ſown Purſlain, ſome of which had been ſteep'd in Salt-Petre Water, and other not, at the ſame Time and Place; ſome Days after which the Nights were ſo cold as to make Ice; and I having found by former Experiments, that in the ſtrongeſt Froſts there would be found no Ice in Lye, and little or none in common Pickles; that a Water in which there was as much Salt-Petre diſſolved as could be, being ſet within-ſide, or even without-ſide of the Window, in a little Bottle cloſe to the others in which the Seeds were, that Water was ſo ſtrongly frozen as to crack the Glaſs, the Parts of which were ſeparated more than the breadth of a Straw; it came into my Head, whether ſince the Salt-Petre Water froze ſo eaſily and ſo hard, the Purſlain, the Seed of which had been ſteep'd in the like Water, might not be killed by this Froſt, eſpecially ſince the Sun had hardly appeared during all that time, which was very cold; and going to the Window to ſee, I found that that Seed which had been ſowed after the common manner, was green, and that, that had lain in the Salt-Petre Water, much more advanced in thoſe Parts that remained alive; but that moſt of it was frozen and dead.

From hence I think we may infer, that in order to make Plants grow and flouriſh, not only Salt-Petre, but likewiſe ſomething that proceeds from the Sun is requiſite thereto; to the end, that by their reciprocal Action, they may concur in the producing theſe Effects upon the Earth, and the Plants thereof.

Beſides, that this ſeems to be further confirmed by a common Experiment obſerved by ſome Husbandmen, namely, that when in the Month of *March*, and the beginning of *April*, North and North-eaſterly Winds blow a long while together; and thereupon it is apprehended, that they ſhall have a bad Year, and that the Graſs by reaſon of the cold does not ſpring up, there is oftentimes a very good Crop, and even an early Hay-Harveſt; for ſome Years I obſerved it, and found it always to be true, eſpecially in the Year 1712, when by reaſon of the frequent Northerly Winds in the Spring, ſomebody ſaid to me, that he feared it would be a bad Seaſon, and that Hay would be ſcarce; to which I anſwer'd, that I had often found the contrary, and that if it were but followed with a good warm Sunſhine, the Graſs would perhaps be early ripe, and there would be a great quantity of Hay, which likewiſe happen'd

Now they who allow the Probability of what has been advanced, may eaſily infer the Cauſe from thence, namely, that the frequent Northerly Winds might bring great Quantities of Salt-Petre to us, which being ſucceeded by the Southerly

Winds, and the Solar Matter that accompanies them, a great Quantity of thoſe Particles which act upon each other, and contribute to Fertility, is then found in our Air; tho' on the other ſide it may ſo happen, that the Northerly Winds ſhall be ſo ſtrong and laſting, and the Southerly ſo weak, and the warm Weather ſo little, that the Aërial Salt-Petre may be as prejudicial to the Fruits of the Earth, by reaſon of its too great Plenty, as the common Salt-Petre (the Experiment whereof is mentioned above) which being uſed in too great a Quantity, killed the Plants. With this agrees the common Proverb of the Husbandmen, confirmed by numerous Experiments, that *a Peck of* March *Duſt is worth a King's Ranſom.* That Month being commonly dry with us when the North Winds blow, by which the Air is render'd ſo heavy, that the watry Vapours will remain floating in them, and cannot deſcend in Rain, which with Southerly Winds are wont to come plentifully down at the ſame Seaſon.

SECT. XV. *Convictions from the foregoing Obſervations.*

I HAVE dwelt the longer upon this Matter, not only becauſe the abovementioned Experiments require to be expreſſed and propoſed with ſome Clearneſs in their Circumſtances; but particularly in order to ſtir up others that have Inclination and Conveniences, to inquire more narrowly what it is properly that renders Lands fruitful, and makes Plants grow more freely; to the end that they may either corroborate what we have here ſaid, by farther Experiments; or otherwiſe, if they find that the Works of Nature exert themſelves after a different manner, they may communicate their Lights to the World; ſince there ſtill ſeems to be wanting numbers of Experiments: For Inſtance, how to order ſuch an Earth, or ſuch Seeds, ſo as that in a few Hours a Sallad, or other Plants fit for uſe, may be produced; or again, that each Seed may at the ſame time put forth all the Seed-Plants contained in it, and make them grow equally, by which means the Fruits ef the Earth might be multiplied; and ſuch like Experiments. At leaſt every one will readily agree, that this is a matter, the Inquiry into which may not only much more illuſtrate our Knowledge of Nature, but likewiſe be very beneficial to Mankind.

In the mean while, ſince nobody can be ignorant that the Air is the Magazine or Treaſury, from whence that which renders the Earth fruitful is communicated thereto, as the frequent plowing and turning up the Earth, and expoſing it to the Air, has ſhewn experimentally for many Ages; can it be thought that it comes to paſs without a wiſe Providence, that there has never been any Want in the Air, of ſuch Particles as are fit for that purpoſe? That the Waters of Rain, Dew, and Snow, falling down through the Air, are impregnated therewith, in order to carry ſuch Particles along with them, and to inſinuate them deep enough into the Earth, ſo as to fertilize the ſame, and to diſpoſe it to furniſh all living Creatures with Food and Refreſhment?

CONTEM-

CONTEMPLATION XXVIII.

Of the Poſſibility of the RESURRECTION.

SECT. I. *The Objection of the* Saducees *anſwer'd by our Saviour,* Matt. xxij. *v.* 29.

I Should here have made an end of contemplating the Laws of Nature, becauſe an Inquiry into all thoſe, to which the Study of Nature, and particularly Chymiſtry, leads us, would take up too much of our time here: But ſince it may ſeem to contribute very much towards the illuſtrating a Matter which is of great Importance, I ſhall attempt to ſet that matter likewiſe in ſome Light, tho' it is ſeldom handled upon Natural Principles. To enter therefore upon it:

It is well known, that among thoſe unhappy Perſons who deny the GOD that made them, there be many who are wont not only frequently to ridicule the Confeſſion of Chriſtians about a Reſurrection, but likewiſe to oppoſe the ſame after all imaginable Ways; and that others, who ſeem to treat this matter with more Reaſon and Decency, are likewiſe accuſtomed to form ſome Objections againſt it, by which they think they do ſufficiently prove the Impoſſibility of a *Reſurrection.*

I know very well, that in order to cut off all Difficulties and Cavillings raiſed againſt this Article of our Creed, by thoſe who acknowledge a God, and believe the Holy Scriptures, nothing can be more ſtrongly returned, than what our Lord was pleaſed to anſwer to the *Saducees* who deny'd a Reſurrection: *Ye do err, not knowing the Scriptures, nor the Power of God,* Matt. xxij. *v.* 29. That is to ſay, the Word which you admit to be Divine, ſays ſo; and no body ought to doubt, whether the Power of God be great enough to perform what he has ſaid.

SECT. II. *It is not a greater Miracle to Raiſe a Body, than to Create it.*

BUT ſince we have here to do with a ſort of deplorable Diſputers, who have no Reverence either for God or the Scriptures, and who think that they are able to prove from their Philoſophy, the Improbability, if not the Impoſſibility thereof; I have been of Opinion, that altho' the Certainty of a future Reſurrection can only be deduced from the Word of that God who never deceives any one, and that the Manner of it muſt likewiſe be referred to his Wonder-working Power; yet that it might be perhaps uſeful to ſome, to ſhew here, that all the Objections which they can raiſe againſt it, are far from having any Strength in them: But on the contrary, that the few as yet known Laws of Nature and Appearances are more than ſufficient to anſwer them all, at leaſt all that have ever occurred to me, and to put the Poſſibility of the Reſurrection, the Proof of which is our preſent View only, quite out of doubt.

To begin therefore: Let one that denies or doubts of the Reſurrection, tell us whether he is not forced to allow, that all the Food of which his Body conſiſts, as well as the Bodies of all his Progenitors, does proceed from the Earth, or rather is nothing more than a metamorphoſed, or transformed Earth: (If he denies this, let him read what we have ſaid thereupon in the firſt and following

ing *Contemplations.*) 'Tis a plain Conſequence then, that his Body likewiſe proceeds from Earth.

And this being ſo, it is no more ſtrange that his Body which was once Earth, ſhould be raiſed again from the ſame, than that it had acquired or received its firſt Figure from thence. What Impoſſibility is there, that ſo wonderful and dreadful a Power, which made uſe of the Earth to form a humane Body before there was any ſuch Being in the World, without its Knowledge, without its Concurrence, and after ſuch a manner as is unconceivable to him and all other Created Beings, ſhould now again think fit to make uſe of the ſame Earth to the ſame purpoſe, and raiſe him up again from the Dead? Let this Philoſopher ſuppoſe with us, that a Man were born and brought up in a Place where he ſhould be entirely ignorant of the Nature of his Food: If now another Perſon came and ſhewed him a Lump of Earth, out of which Rye and Wheat, or what elſe he might have uſed for Food, were produced; and if he told him, that his Body did not only proceed from, but was likewiſe maintained by this Earth; would not this Denier of the Reſurrection think, as we do, that ſuch a Man would make as many Scruples in admitting the ſame for Truth, as others now do when we tell them, that their Body ſhall once again proceed out of that Earth into which it is turned after Death? And would not likewiſe even the moſt Learned Inquirer of what happens in the World, be as much amazed at the Manner after which his Body is formed out of, and ſupported by Earth? were it not that the Cuſtom of ſeeing frequently how a human Creature is born and nouriſhed, but never how he riſes from the Dead, would ſeem to make this matter more intelligible to him; and, as it happens with cuſtomary things, make him look upon the former with no Wonder.

SECT. III. *Even the common Formation of Bodies is leſs credible than the Reſurrection.*

LET one that denies the Reſurrection tell us, whether the Parts of which his viſible Body is compoſed (for as for the exceeding ſmall *Stamina*, we ſhall take no notice of them here) were not as much ſcattered over the whole Earth about 5000 Years ago, as they will be many Years after his Death, or at the End of the World? (See concerning this matter more largely in the following *Contemplation*, *Sect.* V.) And whether it be more impoſſible in this laſt Caſe, than in the firſt, to collect the Parts ſo diſperſed, and to bring them into order.

Again, if he were ignorant of the Manner by which the Production of Animals is performed, and had had no Opportunities of ſeeing the ſame; let him aſk himſelf whether he ſhould admit it as a Truth, that a human Creature, for Inſtance, lying ſo many Months in a Liquid Matter, like a Fiſh in the Water, could be able to live; whereas now the ſame Creature, if kept but a few Minutes under Water, would periſh? And would not he think, that from hence he might alledge many Reaſons, why 'tis more probable that a Man ſhould be produced, like a Plant, out of a Seed, or at leaſt after ſome other manner that does not ſo directly contradict Experience? And yet he ſees this comes to paſs conſtantly, and always after the ſame manner, without any Variation. Can now the Reſurrection of the Dead appear to him more wonderful, or even ſo much? Since in this laſt Caſe it is only required, that a Body ſhould be produced from the ſame united

Parts; and the Manner after which a Man is now formed does beſides this ſeem likewiſe to run counter to ſeveral plain Experiments, by which it appears neceſſary that we ſhould breathe in order to live; whereas we have nevertheleſs ſufficient Cauſe to affirm, that a Child can live ſeveral Months in his Mother's Body without Reſpiration.

This ſeems to be ſufficiently proved, foraſmuch as the Lungs of a Child that is *ſtill-born* will ſink in Water. *Bergerus*, p. 481. gives us an Experiment thereof, and tells us, that the Lungs of a Child born dead, being put into an Air-Pump, will not ſwell, and when thrown into the Water will ſubſide; the quite contrary of which muſt have happened, if the Child had been born alive, and had remained any time in the Air, ſince ſuch Air is never perfectly diſcharged again from the Lungs, but there will always remain a ſufficient Quantity thereof to cauſe the ſame to ſwell, and to hinder the ſinking. Accordingly we find, that a piece of the Lungs of a Beaſt newly killed, being emptied of Part of its Air by the Pump, will contract itſelf and ſink deeper into the Water than before; but however, it will not ſubſide to the Bottom till, after much Pumping and a good deal of Trouble, the Air be quite exhauſted.

SECT. IV. *The Firſt Objection anſwer'd, namely, That we have no Parents in the Reſurrection.*

BUT to proceed; we muſt not ſtop at this Objection, which to underſtanding Perſons is too Vulgar, *viz.* That the Reſurrection does therefore ſeem incredible, becauſe when we came into the World we had Parents to whom we owed our Birth, and that there were ſo many proper Means at hand upon that Occaſion, but that the ſame will all be wanting at our ſecond Birth or Reſurrection.

Since all that a good Logician can prove from thence is, that there is a Power and Wiſdom capable of providing Means for the Procreation of human Creatures after this manner. Now what Reaſon can be given, that the ſame Power which has been able to do this after one manner, cannot make uſe of other Means for the ſame Purpoſe? The rather, ſince we ſee that God, to manifeſt his Wiſdom likewiſe to thoſe that hate it, is wont to execute the ſame Purpoſes in numberleſs Ways and Methods. It would be unneceſſary to repeat Inſtances here of all kinds of Animals, having done the ſame largely in the beginning of the XXII. *Contemplation*, where we have given an Account of their Motion, Nouriſhment and Generation, in reſpect to which the Inſtruments of each kind of *Fiſhes*, *Birds*, and *Beaſts* are almoſt all differing from each other, and yet they are all procreated, nouriſh'd, and do move themſelves from one Place to another.

So likewiſe when we contemplate the *Plants*, how various are the Ways of putting forth and growing among them? Some grow in Earth, and that oftentimes in one only determinate and particular ſort; others require another kind of Soil; ſome grow upon the Water, and ſome even under Water; one in a warm Climate, and another in a cold; ſome are propagated by the Seed; ſome by a Branch taken off from the main Plant; a third by Setting; a fourth by Grafting; a fifth by many of theſe, and perhaps yet different Methods: And thus are the Views of the Great Creator, of cauſing Plants to continue in their Kinds, executed after ſo many different Ways.

This being ſo, what Impoſſibility is there, that the ſame Power which produced the Bodies of

Men once before by the Means of their Parents, may not perform the ſame again by other Means? And if we only ſuppoſe, that this Great Maker can uſe as many Ways as all Men can invent (wherein nevertheleſs his Power does far exceed all human Inventions; as is plain to thoſe that are wont to inquire into his Works, where they daily learn ſomething new, that perhaps never before entered into their Thoughts) no body will eaſily deny the ſame; foraſmuch as he would paſs but for a poor Philoſopher among the Atheiſts, who ſhould not imagine himſelf capable of forming an Hypotheſis, whereby human Bodies, by a different Diſpoſition and Motion of Parts might be produced after a different manner than now they are.

SECT. V. *The Second Objection, from the Smallneſs of the Parts after Corruption, anſwer'd.*

THOSE that deny the Reſurrection do again think the ſame impoſſible, becauſe our Bodies being diſſolved by Corruption into ſo many and ſo ſmall Particles, it does not appear credible to them, that they can be all again replaced in their neceſſary Order, nor the *proper* Body thereby reſtored to its former Figure. But will they therefore doubt, whether a good Anatomiſt can put all the Bones of a Skeleton, or a good Clock-maker all the Wheels and Pieces of a Watch, tho' jumbled together without any Order, into the ſame Structure again, ſo as to compoſe the very ſame Skeleton and Watch? If therefore we do but ſuppoſe, that the Great Creator of the Univerſe is endowed with only ſo much more Wiſdom and Power than an Anatomiſt and Clock-maker, as the Structure of a human Body is more noble and curious than a Skeleton or a Watch, what Difficulty can there yet remain? For that we do not herein aſcribe too much to that Adorable Being, but on the contrary think of him much too meanly and below his great Perfections, by ſuch a Suppoſition, may appear from hence; that if all the beſt Workmen in the World ſhould lay their Heads together, there would not be Wiſdom enough in them, (to ſay nothing of their Power) to put in order the Body of a Flea, or any other Inſect, or even any little Seed of the ſmalleſt Plant, ſo as to compare for Excellence and Contrivance with any one of thoſe which we daily obſerve to proceed by Millions out of the hand of this Great Artificer. The rather becauſe, as has been ſhewn before, the moſt minute Particles, even thoſe of Light itſelf, are governed by a Power which extends itſelf to all things, and they are ſubject to certain and fixed Laws, even when they appear to be in the greateſt Diſorder. Having often ſeen the Picture of a Man ſo accurately formed upon a white Cloth, or Paper, in a dark Chamber, it occurred to my Mind as an agreeable Type of the Reſurrection; at leaſt it appeared from thence, that the Rays of Light reflected from the real Body of a Man ſtanding out of the Chamber, paſs through the Air mingled among numberleſs others that proceeded from circumjacent Objects, and yet, after entering into the Chamber, were ſeparated from all the foreign ones, and collected into the exact Image of the ſame Man, according to the Laws of *Dioptrics.*

If now all theſe Particles of Light, after ſo many Mixtures with, or Percuſſions againſt other Particles, can be oblig'd ſo ſtrictly to obey certain Laws, that when received upon a white Paper, and regularly collected, they will paint and expreſs the juſt Form of that Perſon from whom they proceed; what Impoſſibility is there, that the Parts of a putrified Body, tho' mingled and diſperſed among an infinite number of others, ſhould be brought together again, and compoſe the ſame Body, any more than that the Particles of Light do the Figure of it?

If this be not ſufficient, our Reader may recollect what has been ſaid in the two preceding Contemplations, *viz.* that not only the ſmalleſt *Animalcula*, or Particles of Bodies, cannot eſcape the Direction of the Glorious Maker and Ruler of all things; but alſo and chiefly, that before all greater Bodies do become Inſtruments of his Power, he has thought fit, for the diſplaying of his own Glory, that they ſhould be firſt divided and ſeparated into Particles of the extremeſt Smallneſs, and ſuch as can be ſcarce conceived by Men. If then it be proved by undeniable Experiments, that there is a Power which has framed all things upon the Earth round about us, yea, even the great and glorious Body of the Sun itſelf, of ſuch ſmall Particles, and has diſpoſed them in ſo wonderful an Order; how can the moſt unhappy Sceptic, or Doubter of the Reſurrection, pretend with Reaſon to deduce any Argument from the unconceivable Smallneſs of the Particles into which a human Body after Death may be diſſolved by Corruption or otherwiſe, againſt the Poſſibility of the Reſurrection of ſuch a Body?

SECT. VI. *The Third Objection, from the Attrition of the Particles, anſwer'd.*

BUT as the Fancies of ſome, who wiſh that all their Notions may be true, are rich in finding out plauſible Arguments in favour thereof; ſo they endeavour to amuſe themſelves with the Opinions of ſome famous Philoſophers, who maintain that every thing, eſpecially the ſmalleſt, and conſequently the weakeſt Particles, wear away with Motion; and therefore change both their Figure and Properties, ſo that after a great many Years, and the paſſing away of Ages, we do in vain ſeek throughout the whole Univerſe for thoſe Parts of which a Body was compos'd, and of which, if they were to be found, it might be again compoſed after the ſame manner.

But he who contemplates the Operations and Laws that have already obtained in the World, will be convinced;

Firſt, That by the Art and Invention of Men, whereby they apply the Laws of Nature to their own Purpoſes, even the whole Frame of the Bodies of Men and Beaſts may be preſerved, unchanged, and uncorrupted; it is therefore much more poſſible, and likely too, that incomparably ſmaller Particles may by an unconceivably greater Wiſdom and Power be continued in their preſent State and Condition. Now that the aforeſaid is true, will appear from the known Manner, after which ſo many exotic Plants and Animals are ſecured from Corruption in Spirits of Wine, refin'd from all their Water, with the Addition of a little Camphire; as likewiſe from the embalming of Dead Bodies, as well by the Ancients, as particularly by the Moderns, who can much better ſecure Bodies from Putrefaction. So likewiſe *Simon de Vries*, in his Deſcription of *Old Greenland*, ſays, that the Air is ſo ſharp, as to preſerve dead Bodies from Corruption; and the famous Geographer *Sanſon* relates, that when a *Spaniſh* Colonel marched from *Peru* to *Chili*, over a high Mountain, ſome of his People were frozen to Death; and that ſeveral Years after, he found them in the ſame Condition, that is to ſay ſitting upon their dead Horſes, and holding their Bridle faſt, their Bodies remaining uncorrupted.

Secondly, That all Things do not wear away and change their Figures indifferently, has been already ſhewn in the XXVI. *Contemplation*, *Sect.* V. ſince if it were ſo, Water, Air, and the whole World in all its Parts would be changed as to their Nature and Properties, juſt contrary to what Experience teaches us.

And if any one deſires to be convinced thereof, by an Experiment, which I had made with another view, in order to ſhew, that the Temperating of Acids (as it is called in the Language of the Phyſicians) does not conſiſt ſo much according to ſome, in the obtunding or blunting the acute Parts of the Acids themſelves, as in their ſtrict Union with Alcali's, either Watry or other Parts; let him firſt diſſolve Silver in the Acid Spirit of Salt-Petre, or otherwiſe in *Aqua fortis*, and then after having put a little Water to it, lay a Plate of Copper in the ſaid Liquor, whereupon the Acid will let the Silver go, and diſſolve the Copper. But if you throw in ſome Iron, the Copper is precipitated, and the Iron diſſolved by the Spirit, which being filtrated again by the Addion of ſome *Lapis Calaminaris*, the *Aqua fortis* quits the former, and diſſolves the ſaid Stone. If then you ſhould pour off this Liquor from all that has ſubſided in it by Filtration, and then put ſome Lixiviate Salt of Tartar to it, this laſt will be diſſolved and precipitated, and the Salt be united with this *Menſtruum*; ſo that this mixture being Chryſtaliz'd, (which is a Sign, that the Parts of the Nitrous Spirit remain unchanged,) will yield a burning Salt-Petre.

And to ſhew farther, that it preſerves its Acidity, I put freſh Water and Oil of Vitriol to the aforeſaid Salt-Petre; from whence by Diſtillation, I produced again the ſame *Aqua fortis*, or Spirit of Nitre, which upon tryal, diſcovered

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its Acid Qualities; for when we threw into it ſome unruſted Filings of Iron, I obſerved the Iron to be diſſolved, with a great and violent Effervеſcency, and a very red Vapour to aſcend, which is peculiar to a Nitrous Spirit. This was yet more ſtrongly confirmed, by putting ſome Salt of Tartar to it again, by which means there reſulted the ſecond Time a good Salt-Petre from the ſaid Spirit: From which Experiments it does appear at leaſt, that this Nitrous Spirit, after ſo many, and ſuch different Unions with Silver, Copper, Iron, Calamine-ſtone, and Salt of Tartar, and after having twice reſiſted ſome of them, ſtill remained in its former Condition, the Particulars thereof being neither changed nor worn by all theſe Motions; which ſhews it is by no means impoſſible, that the ſame Power which preſerves to the Spirit of Salt-Petre its Figure and Properties, after ſo many Unions, Mixtures and Effervеſcences, may likewiſe do as much in the Parts of other Bodies. Thus we alſo ſee Quick-ſilver and Gold handled numberleſs ways by the Chymiſts; and yet continue the ſame, after having undergone ſo many Changes.

SECT. VII. *The Fourth Objection, from the Union of theſe Particles with other Bodies, anſwered.*

ANOTHER Objection is wont to be made by ſome, againſt the Poſſibility of a Reſurrection, becauſe, that not only all Bodies are divided into ſuch ſmall Particles by Corruption and other means, but chiefly becauſe theſe Particles become united, or rather changed into other Bodies; and the Earth, which for inſtance, proceeds from a Putrify'd Carcaſs of Man or Beaſt, is oftentimes tranſmitted into many kinds of fluid and ſolid Bodies, ſuch as Water, Air, Trees, Plants, and Herbs; ſo that there ſeems to be neceſſary here, not only a bare Union of theſe divided Particles, but likewiſe, *Firſt*, A Separation from thoſe Bodies wherewith they were united; which to theſe Objectors ſeems incredible, and hardly poſſible in ſo many Millions of Caſes, in which all this would be requiſite towards the raiſing of one only Body again.

But thoſe Gentlemen would eaſily paſs to other Opinions if they were reaſonable, upon our ſhewing them what they look upon as incredible, is brought about many Ways in Chymiſtry, both in reſpect to Solid, as well as fluid Bodies.

If one put Silver into *Aqua fortis*, it will be diſſolved therein, and turned to a fluid Matter; add a little Copper, and the Silver will be ſeparated and ſink to the Bottom, as we have ſhewn before.

Melt Gold and Silver together, and when they are cold, they will become a hard mixed Metal; but throw that Mixture into *Aqua fortis*, and they will be immediately ſeparated, the Silver incorporating itſelf with that Liquor, and the Gold ſubſiding like a Powder to the Bottom; as is well known to all that deal in thoſe Metals.

The Oil or Salt of Tartar being diſſolved in Water, and boiled with Sulphur, will unite itſelf therewith, but pour a little Vinegar into it, the Salt of Tartar will mix itſelf with the ſame, but the Sulphur will be ſeparated.

Mingle Spirit of Sea Salt with ſome Volatile Salt, for inſtance with that of Harts-horn, and they will unite themſelves cloſely to each other; but add ſome Pot-Aſh or Chalk thereto, and they will preſently quit each other, and the Spirit of Salt will join its ſelf to its new Gueſt. It would not be difficult for thoſe that are well vers'd in Chymiſtry, to produce innumerable other Examples of Matters that adhere and unite cloſely with one another, which yet are eaſily ſeparated by the Addition of the Third. And if it happens ſo in theſe Caſes, where is the Impoſſibility in any other Matters?

SECT. VIII. *The Fifth Objection, That in the Particles of Bodies, we cannot obſerve any ſuch Union, anſwered.*

BUT it may be, our unbelieving Philoſophers will reply, that we cannot obſerve any ſuch uniting Properties in the Parts of human Bodies, and that therefore there is no ſuch Thing.

But if they would pleaſe to attend to other Chymical Experiments, they might ſee that Water and Oil being put together, will not unite, but remain unmixed; but if you ſhould join the ſame Oil with Pot-Aſh, and Salt of Tartar, or any other good Lixiviate Salt, (or even ſome Oils with Sugar) and make it into Soap, it will eaſily unite with Water.

Copper is likewiſe indiſſoluble, and will hardly be touched by common Water; but if you add thereto ſome Volatile Salt of Sal-Armoniac, the Copper will be entirely diſſolved, and turned into a blue Liquor.

Reſin made of Drugs, ſuch as *Jallop*, *Scammony*, &c. cannot be ſeparated in ſimple Water; but add to them Yolk of Eggs, or pounded Almonds, and they will be eaſily mixed together; from whence, as alſo from a great Number of other Experiments which we might borrow from the Chymiſt, it is plain, that tho' two Matters will not unite, the ſame may be brought about by the Addition of a Third: And having ſhewn this in ſo many Caſes, what Impoſſibility is there again, that the Material Particles of our Body, according to the ſame, or other Analogous Laws of

Plants and Animals wherewith they have been united, may after a Separation be joined again as they were once before?

SECT. IX. *The Sixth Objection, That theſe Particles are ſcatter'd too far from each other, anſwer'd.*

IF any Body that ſeeks for farther Evaſions, ſhould hereupon reply, that theſe Particles before they can be united to others, muſt firſt be brought very near together; but that between thoſe of our Body, there are oftentimes found very great Diſtances, and that their Union is thereby prevented; let him conſider, that tho' Acids and Alcali's muſt come very near, before they can lay hold on each other, yet Amber, Wax, Glaſs, will attract Straws, and other light Matters at a much greater Diſtance, only by being a little rubbed; that the Load-Stone draws Iron, tho' it be yet farther off, and that whatever is counted heavy upon the Earth, moves, or is attracted towards the Centre thereof; not to repeat here that which muſt be ſuppoſed, according to the Opinion of Sir *Iſaac Newton*, and whereof we have given a Proof above in the XXVIth *Contemplation*, viz. that even the Heavenly Bodies at their great and almoſt immeaſurable Diſtances, are ſubject to a Law that brings them towards each other. If then it appears from hence, that ſuch great Bodies gravitate or move towards each other according to the preſent Laws of Nature, tho' at ſuch great Diſtances, and as far as their Motion will permit, do unite with one another; why ſhould it be impoſſible for the ſame Power to do this in Human Bodies?

SECT. X. *The Seventh Objection, That the Particles of Matter would act with Choice or Knowledge, anſwer'd.*

THERE is another Objection, namely, that the Particles of our Body might ſeem to act with Judgment and Election, if among ſo many Millions of others they ſhould juſt meet at the ſame Places of the Body to which they belong, and concur with them in forming a new Structure.

Yet this is no greater a Wonder, than that among ſo many other Places where the Particles of the Earth, Water, Light and Air might fix themſelves, thoſe that are proper to produce Grapes, do only unite themſelves to Vines; thoſe of Apples, to Apple-Trees; ſuch as belong to wholſome or unwholſome Plants, are united after the ſame manner; and notwithſtanding that the moſt poiſonous Herbs grow near, or in the midſt of a great quantity of Corn, this laſt will not be affected thereby.

The like may be obſerved even in our own Bodies, where from a mixed Chyle conſiſting of ſo many kinds of Meats and Drinks, thoſe Particles are only join'd to each Part of the Body where they are wanting for the ſupport of the ſame; by which Direction it comes to paſs, that Fleſh, Bone, Membranes, *&c.* do all remain unmingled, and in order; without which they would otherwiſe be ſoon uncapable of diſcharging their Functions.

And to give other Inſtances, of which we may find a great many in Chymiſtry; mix Iron, Lead, Salt and Stone, all of 'em reduced to a Powder, together; then hold a Load-Stone near it, it will draw the Iron only, and as it were by free choice out of this Compoſition, leaving all the reſt of the

Matters untouched: Pour Quick-Silver upon this Powder, it will only embrace and unite its ſelf to the Lead, neglecting the reſt; put ſome Water to it, that will only imbibe the Salt, and let all the reſt alone. The Doctrine of the *Menſtrua* or diſſolving Liquors, will furniſh us with a great Number of other Inſtances, wherein each acts upon its proper Object, as it were by free Choice and Knowledge.

Now there is not more required to the Renovation of our Bodies from their Atoms or Particles, than what we ſee in theſe Matters.

SECT. XI. *The Eighth Objection, Concerning* Canibals *or Men-eaters, anſwer'd.*

BUT the Hiſtories which we read of Men-eaters, ſeem to be of ſome Weight with thoſe who would inſinuate this Notion of the Impoſſibility of the Reſurrection into the Minds of weak Men: Since when one Man is devoured by another, the Conſequence would ſeem to be, that as one is turned into the Food of the other, his Body would likewiſe be changed into the Body of the other; and foraſmuch as it is an Article of the Chriſtian Faith, that each one ſhall riſe with his own Body, they think they can prove it to be impoſſible in this Caſe; becauſe, tho' the Body of the *Canibal* ſhould be raiſed in all its Parts, yet that of him who was devoured, will be deprived of ſeveral.

Now to remove this Difficulty; theſe Objectors muſt be forced to own, that two Caſes may come to paſs therein. The *Firſt* is, when the Canibal lives ſome Years after the Perſon he has devoured, for in this Caſe it is clear, that the Objection will fall to the Ground, becauſe, according to the common working of Nature obſervable in all Bodies, that which now tends to Food, and to compoſe a part of the Body, may be ſeparated there-from long before its Death; for if in the Body of any one who daily makes uſe of Food, the Subſtance did not leſſen; and if only one Ounce of that Food which a Man takes each Day at every Meal, ſhould be converted into the Matter of his Body, there would be added every Year 20 Pound to the Weight thereof, and Conſequently in 50 Years, it will amount to above 1000 Weight; whereas we find it otherwiſe by Experience: From whence we may conclude, that as the Body becomes heavier and bigger by Food, it does at the ſame time grow lighter and leſs by Perſpiration, and other Motions of the Fluids, as *Sanctorious* has firſt obſerved.

If now we ſuppoſe *the Second Caſe*, and in order to make all the Conceſſions that are reaſonable, allow that this Canibal or Man-eater does die at ſuch a time as the Objector himſelf thinks fit; and that the Fleſh of the Perſon devoured is united to the Body of him that eats it: This Objection may ſeem at firſt ſight to thoſe that have not much contemplated the manner of God's working in Nature, to carry ſome Force with it.

But let theſe Objectors conſider, that altho' the Maker of a Human Body permits ſo many Things to come to paſs therein with our Knowledge, and at the command of our Will, yet he excepts the Nouriſhment of the Body out of it, that being performed not only without any Power of the Will, but even without our Perception or Knowledge: Since after that the Food has paſſed thro' the Stomach and Bowels (where indeed ſometimes we have ſome Perception thereof) no Body knows what becomes of it afterwards, nor with what Parts, nor at what Time it is united: Shewing thereby, that this Benefit which is procured to us by the taking of Food, depends perfectly and only upon his Will. We ſee likewiſe that ſome ſickly Diſpoſitions, as alſo too great Heat, too violent a Motion, too great a Paſſion, which laſt are not wont wholly to deprive us of Health like bodily Diſtempers, are oftentimes the occaſion that our Bodies are not nouriſhed by the Food that is uſed, ſo well as at other times.

From whence it is probable, that if the Deſign of the great Creator of all things be, that every Man ſhould Riſe with his own Body, as he has declared to us in his holy Word; 'tis likewiſe in his Power to hinder, that no one Particle ſhould eſſentially belong to two Bodies, and that even, after a natural manner, there is no Impoſſibility in it.

But if this Argument ſhould not appear ſufficiently convincing to ſome, they may be aſſured thereof by numberleſs Chymical Experiments; by which it will appear, that tho' a Body has the Property of uniting itſelf to another, yet it can be hinder'd by the Addition of a third, and by other Ways too from doing the ſame.

Thus Spirit of Salt-Petre will unite with Steel; but if one firſt puts into it a fixed Alcaline Salt, ſuch as that of Tartar, the aforeſaid Effect will be prevented.

A Lixiviate Salt will mix with Oyl, and turn it into Soap; but put a little Vinegar to it, or any other acid firſt, and the Salt will not Incorporate with the Oyl; and even when the Mixture is actually made, they will be divided and ſeparated thereby.

Iron will join itſelf to the Load-Stone, or rather they will move towards each other; but turn them only the wrong way, and they will fly from, or drive one another away. But to Inſtance in no more Caſes, as one might eaſily do from Chymiſtry, who can give any Reaſon why

The ſame Power that does all theſe Things, cannot bring about the ſame Effects in the Parts of a Man, whoſe Body has been united as Food to the Body of a Canibal?

Sect. XII. *Conviction and Poſſibility of a Reſurrection.*

I Know very well, that ſome ingenious and acute Philoſophers may not be at a loſs to fancy Hypotheſes, in order to ſolve the Cauſes of all thoſe Experiments we have produced, and it may be ſuch as may ſeem to have ſome Analogy therewith; and that even all the chymical Phænomena are accounted for, by one this way, by another, that; but it is not neceſſary either to admit or to reject the whole: *Firſt*, becauſe we do not here undertake to inquire into the Truth of thoſe Principles, upon which each Man builds his Syſtem of natural Knowledge. *Secondly*, Becauſe it is ſufficient to our Purpoſe if the Experiments be only true, let People deduce them from ſuch Cauſes, as they ſhall judge moſt conſiſtent with their own Hypotheſis: Foraſmuch as no Body can pretend to prove from ſuch Pores, ſuch a Figure, ſuch a Determination of Motion, ſuch an attractive Force in the Parts of Matter (from which Principles moſt Cauſes are derived in this Age) whether it be poſſible that each of theſe are likewiſe to be found in others; and that the ſame Power which has adapted the firſt to theſe Properties, does likewiſe do the ſame in others, by changing them every time according as it ſhall judge it to be moſt ſerviceable to its great Ends and Purpoſes.

SECT. XIII. *Tranſition to another kind of threefold Objections.*

I MIGHT have made an end here of the Proof of the Poſſibility of the Reſurrection in the ſame *proper* Bodies, were it not that ſome Atheiſts pretend to defeat the ſame after other manners: Namely, *Firſt*, by unadmittable Conſequences, which they think they can draw from thence. *Secondly*, By the ſuppoſition of Things that are poſſible, which notwithſtanding, the Reſurrection of the ſame Bodies makes impoſſible according to their Notions. *Thirdly*, by comparing the Bible with it ſelf (from whence all Chriſtians prove the certainty of their Reſurrection) and by quoting ſuch Texts out of it, which, as they would make us believe, ſeem to have very little agreement with a Reſurrection in the ſame Body. And I hope we ſhall not appear tedious to the Learned, if we ſtill add ſomething here to obviate theſe Difficulties, eſpecially if we uſe no other Proofs therein, than ſuch as are founded upon daily Experiments.

SECT. XIV. *Three Objections of the firſt Kind.*

THE *Firſt* Conſequence then, which they think muſt appear abſurd and unadmittable to every one, is, That in caſe the Reſurrection be made in the *ſame proper* Body, a Child dying ſoon after its Birth, will riſe again likewiſe as a Child, and with an imperfect Body.

The *Second* is, That if any one whilſt he is yet a Child, loſes a Leg or an Arm, and lives afterwards ſome Years, and grows bigger, he muſt believe that when he dies, he ſhall riſe again maim'd, and without Arm or Leg; or in caſe his Body be ſupply'd with thoſe Limbs that are

wanting,

wanting, they will be wholly diſproportional to the reſt.

The *Third* is, That if a Man is to riſe with his *own* Body, it ſeems to them a neceſſary Conſequence, that almoſt all Bodies will be entirely ſpent and waſted, and much ſmaller and lighter than they ought to be naturally at the Reſurrection: Since moſt Men before they die, fall away ſo much through Sickneſs, and ſome are ſo exceedingly waſted by Conſumptions, as to fall far ſhort of that Weight and Size which belong to their Bodies in Health.

SECT. XV. *Objections of the ſecond Kind.*

NOW the *Fourth* Thing which they Object, and which, tho' poſſible in itſelf, they think the Belief of Chriſtians renders impoſſible, is the following: If a Canibal or Man-eater ſhould live a number of Years, and in all that time ſhould uſe no other Food than human Fleſh, it ſeems impoſſible to them that both the Canibal himſelf, and at the ſame time all that have been devoured by him, can riſe again with their own perfect and proper Bodies.

SECT. XVI. *Objections of the third Sort from the Holy Scriptures.*

Now the Objections which they themſelves produce from the Holy Scriptures, are firſt, ſuch Texts where expreſs mention is made of a Reſurrection in the ſame Body; as *Job* xix. ver. 26, and 27. *Tho' after my Skin Worms deſtroy this Body, yet in my Fleſh ſhall I ſee God, whom I ſhall ſee for my ſelf, and mine Eyes ſhall behold, and not another.* And *Paul*, Rom. 8. ver. 11. *He that raiſed up* Chriſt *from the Dead, ſhall alſo quicken your mortal Bodies;* as alſo ſo *Phil.* iii. ver. 21. *Who ſhall change our vile Body, that it may be faſhioned like unto his glorious Body.* We ſhall not repeat all the reſt that are of the ſame Tenour.

Againſt theſe Texts they oppoſe ſome Expreſſions of the ſaid Apoſtle, 1 *Cor.* xv. *ver.* 35, 36, 37, 38. which they think cannot be underſtood conſiſtent with the former; for when before, he introduced an Objector uſing theſe Words, ver. 35. *But ſome Men will ſay, how are the Dead raiſed up? and with what Body do they come!* He anſwered the ſame by a Compariſon of a Grain of Corn, ver. 36. *Thou Fool, that which thou ſoweſt, is not quickened except it die*; ver. 37. *And that which thou ſoweſt, thou ſoweſt not that Body that ſhall be, but bare Grain, it may chance of Wheat, or ſome other Grain.* ver. 38. *But God giveth it a Body as it hath pleaſed him, and to every Seed his own Body.* From which Words therefore they conclude, that we ſhall not aſſume at the Reſurrection the ſame Bodies which are put off at Death; but that they will be other, and different, and ſuch as God gives according to his Pleaſure. So that according to them, this Text ſeems to contradict the former, and likewiſe itſelf, becauſe if a Man ſows any Thing elſe than the Body, that ſhall be, and that God gives to the thing ſown, *a Body as it hath pleaſed him*, 'tis impoſſible in their Opinion to be the ſame Body of that Seed.

Beſides this, ſome of 'em urge other Difficulties againſt *a Spiritual Body*, *ver.* 44, *and* 46. and eſpecially becauſe in *ver.* 50, it is ſaid, *that Fleſh and Blood cannot inherit the Kingdom of God.* This ſeems to them contradictory to the former Paſſages quoted from *Job.*

SECT. XVII. *Our Deſign here is not to deſcribe the Manner of the Reſurrection, which we muſt leave to God.*

BEFORE I paſs on to anſwer theſe Difficulties, I find my ſelf obliged, for the Inſtruction of ſuch Chriſtians as may happen to read this, to premiſe:

I. THAT our View here is not to account for the Manner of the Reſurrection of the ſame Body, which great Myſtery we muſt leave to the Wiſdom and Power of God only; nor have we undertaken any Thing more, than to ſhew that ſuch a Reſurrection involves no Impoſſibility in it; and that the foregoing Objections raiſed by ſome Atheiſts, even from the Holy Scriptures, in order to ſooth and quiet their own Conſciences againſt the Terrors of this Reſurrection, may be eaſily cleared up and removed, from what we find daily paſſing in the World by our own Experience.

SECT. XVIII. *A General Anſwer to all the Objections againſt a Reſurrection, taken out of Scripture.*

II. TO return a general Anſwer to all that theſe unhappy Cavillers, and deplorable Bible-readers (I mean ſuch as only ſift the Scriptures to diſcover Abſurdities therein, as I have known ſome ſuch) fancy they have found in that holy Word, which they can neither reconcile with their own Notions, nor with other Texts that treat of this Reſurrection. I ſay, nothing more is required to anſwer theſe People, than what we find to be expreſly affirmed in the ſaid Scriptures; namely, that in order to underſtand the true HOW, and other Circumſtances of the Reſurrection, we muſt according to the before-quoted Reply of our Lord to the *Saducees*, not only *know* the *Scriptures*, but likewiſe the *Power of God*, if we would not *Err*.

SECT. XIX. *A bare Hypotheſis is ſufficient to ſhew the Poſſibility of any Thing.*

TO diſarm the Atheiſts as much as poſſible of all their Evaſions, it is neceſſary to add, that tho' what we ſhould hereafter produce from natural Obſervations, could not be demonſtrated to be ſtrictly true, but were only a ſimple and naked Hypotheſis, it would carry with it perfectly the ſame Weight and Force in this Matter. Since to prove the poſſibility of any Thing, there ought not to be more required from him that aſſerts it, than only to find out an Hypotheſis containing the manner how it may come to paſs, and which includes no Contradiction in it. I don't think that any Atheiſt will deny this, ſince it is own'd by the chiefeſt of their Sect. To begin then,

SECT. XX. *There is a* Proper *or* Own, *and a* Viſible *Body.*

I. EVERY Man has beſides his Soul, a *Body*, which for ſo far as it can be ſeen by all, we ſhall expreſs by the Name of a *viſible* Body.

II. THIS Body may be termed, in reſpect to thoſe of other Men, one's *peculiar* or *particular* Body, ſince a Man is thereby diſtinguiſh'd from others, and it is the Compoſition of this particular Perſon, and no other.

III. But ſince this *viſible* and *particular* Body does undergo very many Changes, and according to the Difference of Years, and to the good or bad Conſtitution of a Man, and otherwiſe, becomes ſmaller and greater, leaner and fatter, lighter and heavier; and that it is even poſſible that one and the ſame Matter may now belong to the viſible Body of one Man, and afterwards to that of another; as for inſtance, if the Blood of one Man, by a Wound or otherwiſe, ſhould be ſpilt upon the Earth, the Matter of it might ſerve to feed ſome Plant or Fruit, which being afterwards eaten by another, contributes to the Increaſe of his *viſible* Body: And ſince, notwithſtanding all theſe Changes, every *viſible* Body does ſtill remain the Body of the ſame Perſon, it is apparent that there muſt be ſomething in the *viſible* Body which undergoes ſo many Changes, from whence it has a Right to be always denominated the *own* Body of the ſame Perſon, of which Term we ſhall likewiſe make uſe in the following Diſcourſe, in order to make a Diſtinction between the *own* and *viſible* Body of every Perſon.

IV. And thus it is plain, from what has been ſaid, that there is an eſſential Difference between the *own* and *viſible* Body of a Perſon; ſince many Parts of the laſt can be joined to, and ſeparated from it, and even belong to more viſible Bodies than one; but the *own* Body remains fix'd and determined to one and the ſame Perſon only.

SECT. XXI. *This Diſtinction is acknowledged by all.*

V. AND that none may think that this Diſtinction between a *viſible* and an *own* Body is invented by us, and has no Foundation in Truth; it is known that if one ſays of a Man, *that he weighs* 200 ℔. nothing elſe is underſtood thereby, than that it is his *viſible* Body which is of that Weight; but if one ſays, *that ſuch a Man is* 80 *Years old*, it can only be meant of the *own* Body, ſince all the Food that he has uſed in the laſt 10, 20, or 30 Years of his Life cannot be ſaid to have appertained to his *viſible* Body the whole Space of 80 Years.

SECT. XXII. *The* viſible *Body conſiſts of Fluid and of Solid Parts, and of Laws.*

VI. NOW to inquire wherein this *own* and *viſible* Body does determinately conſiſt, it muſt be confeſs'd, firſt, that this *own* Body which helps to compoſe the Perſon, is not the *viſible* Body wholly and ſolely; *See* [*Numb.* IV.] it muſt therefore be contained within the *viſible* Body.

VII. THIS *viſible* Body conſiſts:

Firſt, Of *Fluid Matters*, as Blood, Whey, *Lympha*, Chyle, and Milk in Women that give ſuck, and Water in which the Embryo lies in thoſe that are pregnant; various kinds of Glandular Juices from the *Pancreas*, the Glands of the Stomach and Inteſtines, Gall, Spittle, Sweat and perſpiring Matter, Tears, Snot, Nervous Juice, and others, that have yet no particular Name; to which ſome add, Fat, the bitter Matter in the Ears, that in the Seminal Veſſels and the like, tho' they are ſomething thicker than Liquors or Fluids.

Secondly, Of *Solid Matters*, Fleſh, Bones, Nerves, Membranes, the Teeth, *&c.* The modern Inquirers reduce them all to Bones and Nerves, as we have obſerved already in *Contemplation* XI. *Sect.* 17.

Thirdly, Each *viſible* Body, whilſt it is alive, has its particular Laws; thus there are Laws in Human Bodies, according to which are regulated the Conſumption or Digeſtion of the Food in the Stomach, the Separation of the Chyle from the groſſer or excrementitious Matters, the Sanguification or Converſion into Blood, the Separation of the Humours, the Motion and Nutrition whereby the ſaid Blood is turned here into Bones, there into Nerves and Tendons, in another Place into Membranes, *&c.* beſides Generation and Production. According to theſe Laws, we ſee that when a Piece of Bread is eaten by a Man, a Dog, a Fowl, and a Carp; in the three firſt it is turned into different kind of Fleſh, in the laſt it becomes Fiſh; and the ſame Food makes a white Skin in an *European*, and a black one in a *Moor*, as it makes one Man fat and another Man lean; and we find that Children uſing the ſame Food are ſubject to the ſame Laws; that the Stomach of one digeſts with Eaſe and Pleaſure, one kind of Food, as the Stomach of others does another.

SECT. XXIII. *The* own *Body conſiſts, in a manner, of no Fluid Parts, nor of Laws, but almoſt only of ſolid Parts.*

VIII. So then the *own* Body of a Man muſt conſiſt of one or more of theſe three, *Fluids*, *Solids*, and *Laws*.

It does not ſeem to conſiſt of the *Fluids*, ſince many of them are changed, become more or leſs, and may be intirely ſeparated from the Body, whilſt at the ſame Time it ſhall remain the proper and *own* Body of the ſame Perſon: Thus the Blood daily diminiſhes by the Separation of Humours, and by Perſpiration, and is as daily increaſed by a new Chyle; not to mention great Effuſions of Blood both in Men and Women; of the laſt of whom, I knew one who in a few Years had loſt much more Blood than the Weight of her whole Body was equal to; now whether it was a Blood conſiſting of this or that Matter that flowed thro' her Veins, her Body remained unqueſtionably the ſame proper Body.

Now ſince the Blood does not belong eſſentially to the *proper* Body, neither can all the Humours that are ſeparated from it, be counted to belong to the ſame, foraſmuch as they are daily changed; thus Fat is diminiſhed by Leanneſs, and other Fluids by other Means, from thence we may conclude, that hardly any, at leaſt very little, of the Fluids, are neceſſary to the Compoſition of what we call the *own* Body.

IX. Now that the Laws likewiſe do not belong eſſentially to the *own* Body, is apparent; *Firſt*, Becauſe the ſame are frequently changed in the ſame Men, whilſt they remain in the ſame Perſons: Thus Experience teaches us, that ſick and healthy People, young and old, are not ſubject to the ſame Laws, which holds true both in Men and Women. *Secondly*, The ſame may be inferr'd, not only becauſe the Body is material, and the Laws do only conſiſt in certain Motions and Properties, but particularly (which puts the thing paſt all doubt) becauſe a dead *viſible* Body, in which it cannot be ſaid, that theſe Laws do any longer prevail, is as much eſteemed to comprehend the *own* Body of the deceaſed Perſon, as when it was living.

X. Lastly, Since it plainly appears, from all the foregoing, that a Body may ſtill continue the *own* proper Body of the Perſon, tho' filled with Humours and Juices quite different from thoſe it once had; and that ſuch Fluids may be likewiſe moved by quite different Laws, but even thoſe Laws may alſo entirely ceaſe when the Body is dead; we muſt therefore only ſeek for this proper *own* Body in the ſimple and naked *ſolid* Parts thereof.

SECT. XXIV. *The* own *Body conſiſts either of a* Stamen *or Principle unfolded only; or elſe of a* Stamen, *that grows and increaſes by the Addition of Foreign Particles.*

XI. NOW to treat more cloſely of theſe *ſolid* Parts:

It is very well known to thoſe that are verſed in the Inquiries of the preſent Age, that as the Plants and Animals, ſo likewiſe Man does conſiſt of a firſt Principle or *Stamen*, which may therefore be denominated the *own* Body, or at leaſt ſomething that contains the ſame; as has been already ſhewn in the XVIth *Contemplation.*

The Parts of this *Stamen* are in the Growth of it, and from time to time expanded, or unfolded, and cloathed as it were, and filled up with other Particles continually, till the viſible Body of a bigger, and at leaſt of a full grown Creature, reſults from it.

Now ſince this *Stamen*, during the Growth of a Body, is clad and ſtuffed with other Matter in and about it, and ſince it contains all the ſolid Parts of the Body in Proportion to its Bigneſs, either this ſimple expanded *Stamen*, without any other adventitious Matter, muſt be admitted and allowed to be the *own* Body, or elſe the ſame *Stamen* filled and cloathed with that Matter, which afterwards becomes Bones, Fleſh, Ligaments, Membranes, *&c.* ſo far as thoſe compoſe the ſolid Parts of a Body, muſt be reckon'd the *own* Body; one of theſe is certainly true.

We ſhall therefore, in both theſe Caſes, one of which muſt needs be admitted, endeavour to ſolve the Objections of Atheiſts; and firſt, thoſe which they are uſed to bring from Nature, and next from the Holy Scriptures.

SECT. XXV. *How a Man may be ſaid to riſe again with his* own proper *Body, in the firſt Caſe.*

XII. If it be ſuppoſed that the bare *Stamen* expanded according to the Bigneſs of the Body, without the Acceſſion of any other Matter, to fill and cloath the ſame, be the *own* Body, and which is to continue ſo in all Men from their Birth to their Death; there will be nothing more required, that ſuch a Perſon ſhould riſe with his *own* Body, than that only this *Stamen*, ſeparately from the Particles that cloath and fill the Body, ſhould remain, and be continued in its own little Subſtance, and that the great Author of our Reſurrection ſhould, after Death, unfold, fill and cloath the ſame into a viſible Body, with the ſame Matter that belonged to it before, and in its Life-time, when it was a viſible Body; or elſe with ſuch other Matter as he ſhall be pleaſed to uſe. We ſhall not ſpeak of the altered or changed Properties and Faculties, ſince they do not affect the Matter thereof, nor do change the *own* Body as to its Eſſence; but refer it to the Word of God, touching the ſame.

SECT. XXVI. *The* own *Body, tho' filled with other Matters, remains the* own proper *Body of the ſame Perſon.*

XIII. Before we proceed any farther, let me add two things that may obviate all Objections againſt what has been lately ſaid.

Firſt, That an *own* Body, tho' filled and cloathed into a *viſible* Body with other Matter that never belonged to it, does nevertheleſs remain the *own proper* Body of the ſame Perſon; nor does this want much Proof, ſince any one that has fallen away by Sickneſs or Pain, if after his Recovery he becomes bigger and fatter, and for that Purpoſe has uſed Food that was never any part of his own Body, will always be reckon'd to have been the ſame Perſon, and conſequently to have been alter'd by becoming ſo much more *viſibly* bigger and fatter.

SECT. XXVII. *When any one dies, a great deal of that Matter which belonged to the* viſible *Body, will be ſeparated therefrom.*

XIV. *Secondly,* That when a Man has lived ſome Years, a great Quantity of that Matter which belonged to his *viſible* Body, may be ſeparated from it, and he ſtill remain the ſame Perſon; inſomuch that the *own* Body undergoes no Change by the Loſs or Acceſſion of ſuch Matter that helpt to make it a *viſible* Body.

To prove this, Let us again ſuppoſe a Man that is 80 Years old, and that weighs 160 Pounds, and who, reckoning one Day with another, after Breakfaſt, Dinner, and Supper, unites but one Ounce every Day of the Food he uſes, to the fluid and ſolid Parts of his Body, in order to repair what he loſes by Perſpiration, and other Ways; according to which, without reckoning the Weight of his whole Body as ſoon as he was born, there would be 80 times 365, which is 29,200 Ounces, or 1825 Pounds of nutritious Matter, that has gone towards the Compoſition of his *viſible* Body in the Space of 80 Years; from which if we ſubſtract thoſe 160 Pounds, there will ſtill remain 1665 Pounds, which during his Life-time, when they were at firſt nothing but Wheat, Rye, Fiſh, Fleſh, *&c.* did not belong to his Body, but were quite foreign to it, and might have as well have gone towards the

Compoſition of any other Man's *viſible* Body, as of his; and which afterwards have ſerved to nouriſh his *viſible* Body for ſome Time, and finally have been ſeparated again from it; in all which Caſes none can deny that it has been the ſame Perſon, and therefore always preſerved his own Body, from which, what has been ſaid before is ſufficiently demonſtrated.

SECT. XXVIII. *The three Objections of* Sect. XIV. *anſwer'd, in caſe the* own *Body conſiſts of a bare* Stamen.

XV. Now to return a particular Anſwer to the particular Objections ſtarted by the Atheiſts, *Sect.* XIV, and XV. and which they pretend to raiſe from Nature, upon this Foundation, that the bare *Stamen* does only remain the *own* Body, and is only expanded or unfolded from itſelf into a larger Size, by extending the Parts of it farther from each other (of which an Example may be ſeen in the XVIIth *Contemplation*) there is no need of any other Argument than the following:

If a Child were to riſe again as a Child in its *own* Body, the Matter of its *Stamen* need only be preſerved and be again filled up at the Reſurrection by other or by the ſame Particles by which it had been increaſed before.

If a Perſon is to be raiſed as full grown, the aforeſaid *Stamen* needs only to be expanded after the ſame manner as it would have been in the Life-time, and then filled up and cloathed with Matter, which, when it remained alive, and increaſed in Bulk, would have ſerved for filling up the ſame; in which Caſe, every one muſt acknowledge, that the ſame Perſon would have riſen again in his *own proper* Body.

The ſame may likewiſe be ſaid, if any one that is now a Man, and had loſt a Leg or an Arm in his Childhood, ſhould die; for here it is only requiſite, that that Part of the *Stamen* which was to compoſe the Arm or Leg, ſhould be expanded, filled up, and cloathed, in Proportion to the bigger Body, as has been ſhewn before concerning the ſmaller.

Moreover, if any one dies lean and waſted, and at the *Reſurrection* his Body is filled with Matter, which did either never belong to him, or otherwiſe, with ſuch as had before filled up his *own* to a *viſible* Body, why ſhould he, at the *Reſurrection*, be leſs accounted the ſame Perſon, and be reckon'd leſs to enjoy his *own* Body, than *Job* is ſaid to remain the ſame *Job*, and to have retained his *own* Body, as well, when by the Goodneſs of God he was reſtored to his former Strength and Health, as when he was ſo waſted, as to be able to ſay of himſelf, *Chap.* xix. *ver.* 20. *My Bone cleaveth to my Skin and to my Fleſh, and I am eſcaped with the Skin of my Teeth?* Now it is very probable, that that which render'd his *viſible* Body bigger and heavier after his Recovery, conſiſted of ſuch Food and Matter as did not before belong to the ſame.

SECT. XXIX. *The Objection in* Sect. XV. *anſwer'd upon the ſame Foundation.*

XVI. Finally, if now even a *Canibal* had, during his whole Life, fed upon nothing but the Matter of the *viſible* Bodies of Men, and it had only pleaſed God to hinder that the *Stamina* of all thoſe whom he had devoured ſhould have been converted into Food, but that they ſhould have paſſed thro' his Body with other excrementitious Matter; what Impoſſibility is there that the particular *Stamen* of each Perſon (which we here ſuppoſe to be the *own proper* Body) ſhould be ſeparated from thence, and filled up again by other proper Matter, or, it may be, by ſome that had ſerved the ſame Purpoſes before, as well as other dead Bodies. For it has been already ſhewn, in *Numb.* XIV. that when a Perſon dies after ſome Years, there are always a great Number of Particles ſeparated from his Body, at the Time of Death, which had ſerved before to the filling up of a *viſible* Body.

Thus likewiſe may the *Stamen* of the *Canibal* himſelf remain alone, without any of its expanding Fluids, and be filled up with others at the *Reſurrection*, and he accordingly may riſe likewiſe in his *own* Body. For who can deny that any Man, for inſtance, that has lived twenty Years upon human Fleſh, and after that, fifty Years more upon Bread, does not, in both theſe Caſes, retain his *own* Body? For which Reaſon the proper Body of any Perſon does remain the ſame *proper* and *own* Body, tho' filled up with other Fluids. *See* Sect. XXVI.

SECT. XXX. *The* viſible *Body of a Man may be very much emaciated, and yet remain his* viſible *and* own *Body.*

XVII. NOW to paſs on to the ſecond thing mention'd in *Sect.* XXIV. and to ſolve the Objections of the Atheiſts by this other Principle, that the *own* Body of a Man does not only conſiſt of the ſimple *Stamen*, but does moreover always comprehend ſome of the filling and cloathing Matters which adhere to the ſaid *Stamen*, altho' what has been already mention'd be ſufficient to demonſtrate the Poſſibility of a Reſurrection in the *own* Body, againſt all Atheiſtical Evaſions whatſoever:

Let me here premiſe, that it is experimentally known to many, that the *viſible* Body of a Man may be extreamly emaciated, or become very lean, and yet remain his *own*, and likewiſe his *viſible* Body. Accordingly two Inſtances, among many other, do particularly recur to my Mind; the firſt was of a Perſon who had before been very Muſculous and Fleſhy, but was, without any viſible Feaver, ſo exceedingly reduc'd by a *Maraſmus* or *Leanneſs*, that his Legs and Arms, and all his Body beſides, appear'd to them that ſaw and felt him, to be nothing but Bones or a living Skeleton; his Skin was all over blackiſh and very hard, cleaving almoſt inſeparably to the Bones; nor could we externally diſcover the leaſt Softneſs of any Muſcles, of which, notwithſtanding, the ſolid Parts remained under the Skin.

The Second, who was likewiſe before a very corpulent and fat Man, upon the burſting of three Veſſels in the Lungs, call'd by the Anatomiſts *Vomicæ Pulmonum* (from the leaſt of which, there proceeded by Coughing and Retching as much Matter as would fill half a common Baſon, and from the biggeſt much more, in leſs than an Hour's time) was in a little while reduced to ſuch a Leanneſs, that his Fleſh was quite waſted; and the ſame was attended likewiſe with a continual Cough, which laſted even a great while after he was aſleep. Notwithſtanding which, both theſe Perſons afterwards recovered their Health to ſuch a Degree, that the firſt of 'em was again plump and fleſhy, and the other grew extreamly fat. I have related both theſe Hiſtories, becauſe no Body ever queſtion'd, nor can it at all be doubted, that theſe Men, in both theſe ſo different Caſes, were the ſame Perſons, and that their Fat as well as their Lean Bodies might and ought to be denominated their *viſible* and *own* Bodies.

SECT. XXXI. *The* own *Body, tho' allowed to be a* Stamen, *with an Accretion of foreign Matter, conſiſts of nothing elſe but of ſolid Particles, and chiefly of Bones.*

XVIII. BEFORE we proceed, it muſt be here again obſerv'd, that the *own* Body of a Man, tho' conſiſting of a *Stamen*, increaſed with other Matters is, as has been already hinted, only compoſed of *Solid* Parts; foraſmuch as the *Fluids* and the *Laws* are daily changed, and the laſt of 'em do entirely ceaſe at the Time of our Death.

Moreover, ſince a viſible Body, tho' reduced to ſuch a Leanneſs as we have juſt now ſhewn, may continue to be the *viſible* Body, having never been entirely deprived of its Fluids during its Leanneſs, the *own* Body muſt be ſtill leſs in Matter than the emaciated viſible Body.

Finally, that this *own* Body does conſequently conſiſt of nothing elſe but Bones and Nerves, of which likewiſe the Membranes, and of them the Tubes of the Fleſh are compoſed, (*See Contemplation* XI. *Sect.* XVII.) and the ſaid Fleſh, when the Blood and Humours are ſeparated from it, is ſo very ſmall a Part of the *viſible* Body, that it can hardly be ſeen, nor even felt externally in the greateſt Leanneſs; ſo that from hence it appears, that the real *own* Body does chiefly conſiſt of mere Bones.

SECT. XXXII. *The Three Objections mentioned in* Sect. XIV. *ſolved upon the Suppoſition, that the* own *Body does conſiſt of a* Stamen *increaſed to a certain Bigneſs.*

XIX. Now in order to ſolve the former Objections likewiſe from this Second Principle, of which mention has been made in *Sect.* XXIV. Suppoſe a Child to die, if it be to be raiſed again as a Child, it is unqueſtionable that it puts off by Death its *own* Body in the *viſible* one.

If it be to riſe as a full grown Perſon, it is certain that no Atheiſt can deny, but that this *own* Body of the Child would have been filled up and cloathed with other Matter that never belonged to the ſame, if the Child had lived to Man's Eſtate, and yet it would have remain'd the *own* Body of this Perſon. Now in caſe the Body of ſuch a Child ſhould at its Reſurrection be increaſed with the ſame Matter which would have been made uſe of if it had remain'd living; what Reaſon can there be to affirm, that ſuch a grown Body would not have been the Child's *own* Body in the one Caſe as much as in the other?

The ſame Thing may likewiſe be apply'd to a Perſon, that in his Youth has loſt a Leg, or an Arm, or any other Member; as likewiſe to thoſe Objections, that moſt Men muſt riſe again with meagre and waſted Bodies. Foraſmuch as we have ſhewn above, *Sect.* XXX. that not only a Body almoſt utterly emaciated, but alſo in the Caſe of *Job*, the ſame Body fill'd with other Fluids (ſuch as never belonged to it before) may remain the *viſible* Body of the ſame Perſon; and no reaſon can be given, why that which happens at the Reſurrection to a Body emaciated by Sickneſs, may not likewiſe be apply'd to a Body fill'd with Parts that render it much more beautiful, and denominate it the *own* and *viſible* Body of the ſame Perſon; the rather, ſince ſuch a Repletion or Augmentation may likewiſe be made with ſuch Matter, which even had ſerved before to the filling up of the ſame Body in its Lifetime; of which, at the Reſurrection, there will be at hand a great Quantity, and more than is neceſſary. See *Sect.* XXVII.

SECT. XXXIII. *The Objections of* Sect. XV. *anſwer'd from the ſaid Principles.*

XX. FINALLY, to return an Anſwer to the Difficulty which theſe deplorable Philoſophers think impoſſible to be ſolv'd, and which they fetch from the Example of a *Canibal*, who was ſuppoſed to have devour'd a great many Men, and to have uſed no other Food: Theſe Gentlemen are deſired to obſerve in the firſt Place, that the Foundation of their Miſtake conſiſts herein, *viz.* That the Body of ſuch a Man-eater can be nouriſh'd as well by the *own* as *viſible* Body of one or more Perſons, the contrary whereof is true.

To prove this, can a *Canibal* ſupport his Life (not to ſpeak of his Health) therewith, if nothing but ſuch emaciated Bodies as we have deſcribed above, were allowed him for Food? Can he likewiſe eat Bones that are withered to a greater degree even than ſuch as are dried in the Sun? Can he be nouriſhed with Nerves and Membranes entirely and perfectly diveſted of all their Juices? For a *viſible* Body, though never ſo much emaciated, can nevertheleſs be in no ſenſe eſteemed an *own* Body, as long as there are any Fluids therein, as we have ſhewn above, *Sect.* XXII, and XXIII.

On the contrary, daily Experience teaches us, that what we make uſe of for Food does belong only to the *viſible* Body of an Animal, and the Fluids that are therein. Thus we know that the Gravy of Roaſt-Meat, and the Soup of that which is down-boiled, yields a very hearty Nouriſhment, but that the ſolid Particles belonging to thoſe Bodies upon which we feed, are ſeparated from the Nutricious Juices, and paſs off through the Body.

To conclude; Since now the *own* Body muſt be conſidered abſtractly from any Humours and Juices, and ſince all that ſerves for the Food and Nouriſhment of a Man-eater, muſt only be divided from the *viſible* Body of the Perſon devoured; it is plain, that altho' a *Canibal* had devoured hundreds of *viſible* Bodies of other Men, it would likewiſe happen, according to the common Courſe of Nature, that the ſolid Particles diveſted of all their Juices, or the *own* Bodies of the devoured Perſons, would be diſcharged, or caſt out unmingled with thoſe of the Devourer; and conſequently that each of them might appear ſeparate and entire at the Time of its *Reſurrection.*

SECT. XXXIV. *Convictions from all the foregoing Objections.*

XXI. NOW let an unhappy Atheiſt ask himſelf ſeriouſly, and in his Retirement, whether all theſe Objections which he is wont to fetch from Nature, can ſecure him againſt the poſſibility of a *Reſurrection* ſo much dreaded by him? And if he argues without a Reſolution of not believing the ſame, whether theſe ſtudied Evaſions can free his Mind from the continual Terrors that muſt unavoidably follow the leaſt Reflections of an ap-

approaching Reſurrection, and the Conſiderations of appearing before the Judgment-Seat of that Juſt and Almighty God, whom he has ſo frequently, and ſo unworthily Blaſphemed?

CONTEMPLATION XXIX.

Of Unknown Things.

SECT. I. *Tranſition to Unknown Things.*

SINCE we have endeavoured in the foregoing Contemplations, to ſhew from a very ſmall part of what is known to us both in the great and little World (and we hope likewiſe with unqueſtionable Succeſs) that there is ſuch a Being as a Wiſe, Mighty, and Gracious God; we might here put an end to this Work, were it not that even in thoſe things which are ſtill unknown, and which perhaps will remain for ever unknown to all Men, there did not ſeem to remain ſome Proofs great and ſtrong enough to bring unhappy Atheiſts to a better Mind.

SECT. II. *That there are many Things ſtill unknown.*

IT will not be very neceſſary to uſe many Arguments to prove, that there are an unexpreſſible Number of Things in the Viſible World, as yet unknown to all Men. The different Opinions which prevail among the greateſt and moſt learned Men, about the Cauſes of the ſame Appearances, prove this Aſſertion plain enough; and one might well judge a Man very uncharitable, who when any one among thoſe Learned Men had proved properly and experimentally the Truth of his Opinions, ſhould think of all the reſt, that they could be ſo unreaſonable as to refuſe to comprehend, or ſo ſtupid as not to be able to comprehend this Truth: At leaſt this is certain, that if there be three Perſons of different Opinions, two of them, and it may be all three, know nothing of the matter. And, not to repeat here the Confeſſions which great and famous Mathematicians have made of their Ignorance of many things, with a generous Self-denial (of which one may ſee one Example in the thirteenth *Hydroſtatical Propoſition* of Dr. *Wallis*, and another in the eighteenth *Optical Lecture* of Dr. *Barrow*, *Sect.* 13.) let the proudeſt and moſt ſelf-conceited Atheiſt tell us, whether there is any real particular thing, ſuch as *the ſmalleſt Leaf of Graſs*, or *the moſt contemptible Inſect*, that are perfectly known to him; and concerning which, numberleſs Queſtions might be propoſed to him, whereof he would be ſcarce able to anſwer any; at leaſt, could he tell us concerning one of thoſe, or any other material Being, how the ſmalleſt and original Particles thereof are formed, how diſpoſed, how moved, and what ſort of Pores or Interſtices they make with one another? And even, not to go ſo far, could he with all his Wiſdom be able to ſay, how a thing would appear through a good Microſcope, unleſs he had taken the pains before to examine the ſame? And after all, ſince there are ſo many things which are quite out of the reach of the niceſt Inquiry, one may eaſily conclude, that in each of them there is a great deal that is wholly unknown to him. But this may ſuffice here, ſince I cannot imagine that there is any body who would paſs for wiſe or reaſonable, that will not readily own, *there are many things of which he is entirely ignorant.*

SECT. III. *Atheiſtical Objections anſwered.*

I KNOW very well, that among theſe unhappy Men there are ſome, who to elude the Proofs of a Wiſe God (the very Thoughts of which is dreadful to them) endeavour to ſcreen themſelves againſt the Reproaches of their convinced Minds behind theſe unknown things, ſaying, that if there be ſtill ſo much unknown, how can we extol the Wiſdom of a Great Creator, which can only manifeſt itſelf in the things that are known? To anſwer which, before we proceed any farther, and for the Satiſfaction of ſuch as may ſtumble thereat, we affirm, *Firſt*, That the Wiſdom and Skill of an Artificer is not ſo much diſplayed by the number of Things he has made, as by the Contrivance and Workmanſhip that appears in each of them. For inſtance, need we deſire to ſee any more than one Watch well made and skillfully put together, to judge of the Knowledge of the Maker? And if we ſee but one compleat Picture of a Painter, will it not be ſufficient to acknowledge him to be a great Maſter? Now if this be true, as it cannot be contradicted, I leave it even to the Atheiſt himſelf, whether he muſt not own, that in the foregoing Diſcourſes not one, but very many Inſtances have been produced, of a Wiſdom that governs the World; and conſequently, altho' there be an infinite number of Things ſtill unknown, whether thoſe which we now know are not abundantly ſufficient to demonſtrate the Wiſdom of their Maker: The rather, ſince that in knowing all theſe things, we know a great deal in reſpect of others that have never inquired into, nor read the Diſcoveries in Natural Philoſophy; which, however, is very little, in compariſon of what remains to be ſtill known.

Secondly, Theſe Objectors muſt be told, that a Man may be entirely ignorant of the Structure of a Machine, and of the Manner how it is put together, and yet not be the leſs ſatisfied of the Art and Wiſdom of him that framed it; eſpecially when one ſees that it is accurately and nicely adapted to perform ſome great and uſeful Deſign. For can any body obſerve a good Microſcope, conſiſting of two or three Glaſſes, ſo wonderfully contrived for viewing the very ſmalleſt Objects; or a noble Teleſcope, made uſe of for the clear and diſtinct contemplating the Heavenly Bodies, ſo vaſtly diſtant from us, and conſequently inviſible to our naked Eyes; or a fine Clock, ſhewing the Days, Hours and Minutes, and endued with ſeveral other Motions, and yet perſwade himſelf, that all theſe were made without any Skill or Contrivance, only becauſe the Structure and Diſpoſition of them are unknown to him?

SECT. IV. *Unknown Things, tho' in themſelves not conceivable, do yet prove the Greatneſs of God.*

IF now it be obvious to every one, that from what has been ſaid about Unknown Things, even Reaſon will teach us that God may be magnified thereby; the Wiſdom of his Holy Word, tho' it were not allowed to be Divine, does likewiſe appear as plain from thence; not only becauſe it does not make uſe of any Philoſophical or Mathematical Demonſtrations to prove the Power, Wiſdom and Goodneſs of God; but particularly, becauſe it makes uſe of things that are unknown to Men, and even unſcrutable, in order to convince us of the infinite Perfections of God, of the Meanneſs and Vileneſs of Man, and to ſhew the Reaſons that we all have to praiſe Him and admire his Glory.

To give an Inſtance thereof: Whether we ſuppoſe the World and all material Beings in it, to have been produced in the Beginning by the commanding Word of an Adorable Creator, as is confeſſed by Chriſtians; or whether, according to the Hypotheſes of unhappy Atheiſts (for higher than an Hypotheſis they cannot pretend to go) it ſhould be admitted, that if not the Form, yet the Matter of the World is Eternal: This at leaſt will unqueſtionably reſult from each of thoſe Hypotheſes, that all the Particles of which all human Bodies are compoſed, have exiſted as long as the World, or as long as all Matter itſelf.

Now then no body can deny (becauſe it appears too plain by Experience) that all the Parts of our Bodies did at firſt exiſt in the Food that has been made uſe of for the Growth and Increaſe thereof, and conſequently in Wheat, Rye, Barley, Rice, as alſo in the Fleſh of Oxen, Sheep, all kind of Fowls and Fiſhes, in the Fruits of all Trees and Plants, and, in one Word, in every thing that ſerves to ſupport the Life of Man. Conſequently that they were likewiſe to be found in every thing from whence ſuch Plants and Animals have been produced, that is to ſay, in Earth, Water and Air; and thus tracing them ſtill backwards, we meet with them in every thing whereof this very Earth, Water and Air conſiſts, namely of corrupted and putrified, burnt and conſumed Bodies. So that if we go back from one thing to another, and follow this Thread to the Beginning of the viſible World, muſt not every one that ſeriouſly conſiders the ſame, be convinced, that his Body, and all the Parts of which it at preſent conſiſts, have inceſſantly paſſed from one

Mixture and Compoſition to another, for as many Ages as the World has laſted; ſo that theſe our Hands and Feet, and all the Limbs we now poſſeſs, have, with reſpect to their original conſtituent Particles, been diſperſed and ſcattered thro' infinitely different Places for thouſands of Years paſt, growing in Plants upon the Ground, walking with Cattle in Meadows, flying with Birds in the Air, ſwimming with Fiſhes in the Water, and plowed up in the Furrows of the Earth. And ſince Water and Air likewiſe do bear a part in the Compoſition of our Bodies, the Particles thereof which are now mixed with our own Fleſh, have been exhaled out of Rivers, have aſcended in Vapours, and deſcended in Rain, Hail and Snow, have been kindled in Lightning and other Meteors, have been ſcatter'd in Storms, and wafted backwards and forwards to all parts of the World by the Winds; and thus in numberleſs Places, at numberleſs Times, and after numberleſs Manners, have undergone numberleſs Compoſitions and Mixtures, till they have been finally collected and become the conſtituent Parts of theſe our Bodies.

Now tho' nothing of all this implies any Infinity, or any Incomprehenſibility; yet the moſt ſelf-conceited Atheiſt muſt acknowledge, that neither he, nor any one elſe can ever be able to trace this his Genealogy or Pedigree; nor to ſay in what Figure, in what Structure, or in what Places the Parts of his preſent Body have reſided from the Beginning of the World; and that a greater Knowledge than that of all Men living, is requiſite to return a proper Anſwer to this Queſtion.

And the Almighty ſeems to have propoſed much the like Queſtion to *Job*, to convince him in the ſtrongeſt manner of the Divine Glory and

Greatneſs, and of his own Vileneſs and Nothingneſs, in the following Words: *Where waſt thou when I laid the Foundations of the Earth? Declare, if thou haſt Underſtanding.* Ch. xxxviij. v. 4.

After the ſame manner we find King *David* taking an occaſion to praiſe God, and to acknowledge his Works to be wonderful, from the Things that were unknown to him, but manifeſt to God alone. For after having confeſſed his own Ignorance, and extolled the infinite Knowledge of God in theſe Words of the CXXXIXth Pſalm, Ver. 6. *Such Knowledge is too wonderful for me; it is high, I cannot attain unto it*; he continues to ſay, in the 14th and following Verſes, *I will praiſe thee, for I am fearfully and wonderfully made.* And, as if he did not thereby ſufficiently acknowledge his own Ignorance, he adds, *Marvellous are thy Works; and that my Soul knoweth right well. My Subſtance* (otherwiſe my Bones or Strength) *was not hid from thee when I was made in ſecret, and curiouſly wrought in the loweſt parts of the Earth. Thine Eyes did ſee my Subſtance yet being imperfect, and in thy Book all my Members were written, which in continuance were faſhioned, when as yet there was none of them.*

I ſhould not have repeated theſe things here, having had occaſion to ſpeak of them more than once already, were it not that we find much the ſame Expreſſions about the Exiſtence of a human Body, as are analogous and uniform to the various Obſervations and Diſcoveries of the greateſt Naturaliſts of our Age: And that an Infidel may be fully convinced thereof, let him only read what the great *Harvey* writes thereupon, *Exerc.* 56. *de Ord. Part. in Gen.*

We ſhall find in the aforeſaid Treatiſe, that even in the ſecond Month, the whole Frame of the little Embryo is of ſuch a ſort of inconſiſtent Subſtance, that it cannot be touched without it be laid in Water. Let then the Atheiſt conſider, whether King *David* had not reaſon to ſay, that *he was fearfully made?* And would he not be frighted, in ſeeing how eaſily his precious Body and the tender Limbs thereof may be ſqueez'd to pieces, or turned to a miſhapen Creature, even by the Motion of the Mother's Bowels, and other Cauſes?

Secondly, The aforeſaid Prophet ſays alſo, that he is *wonderfully made*; and after the ſame manner we hear the famous Philoſopher *Harvey* expreſſing himſelf with Amazement, *Mirum dictu*, or, 'tis wonderful to ſay it, how far the *Embryo* or Fruit is in the fourth Month advanced in Bigneſs, being grown from the length of an Inch to a Span.

Thirdly, The Pſalmiſt of *Iſrael*, who names his firſt Beginning *an imperfect Subſtance*, could hardly expreſs this with more Emphatical Words than the abovementioned Author, when he tells us, that in the third Month the little Limbs begin to appear; but he adds, *Rudi tamen formâ*; that is, in a rough or irregular Form; inſomuch that even the Muſcles could not be then diſtinguiſhed, tho' the Fleſh, or greateſt part of the Body be compoſed thereof. And when he proceeds to deſcribe an *Embryo* four Months old, he ſays, that the Head of it was very large, the Face without Lips, Cheeks, or Noſe; that the Mouth was likewiſe very large, and the Tongue viſible therein, but the Eyes were ſmall but without Eyelids; that the Fleſh of the Forehead, which covered the whole Crown was not yet cartilaginous, far ſhort of having acquired the Conſiſtence of Bones. Now what Atheiſt can ſay, that the Holy Scriptures do not without Reaſon compare the Origine of all Men to an *imperfect Subſtance?* The rather, if we add thereto what Mr. *Dodart* ſays in the *Hiſtory of the Academy of Sciences*, 1701, *p.* 26. *It is plain, that a* Fœtus *has very different Proportions from thoſe of a grown Perſon; and*

and that if the Limbs of a Man were made accordingly, they would be quite monſtrous, and hardly paſs for human.

Laſtly, Theſe Expreſſions, *In thy Book all my Members were written, which in continuance were faſhioned when as yet there was none of them,* Pſ. cxxxix. v. 16. do ſhew how well known to him that inſpired the Holy Penmen, were theſe daily Changes of a *Fœtus,* after the ſame manner as they have been obſerved in our Ages by the aforeſaid *Harvey* and *Malpighi,* and as they have been deſcribed in *Birds* by the latter from day to day.

To conclude then; Let an Atheiſt conſider, from the few Paſſages here quoted, and from a great deal more that he will find in the abovementioned Authors, how much is unknown to him of his own Formation, and how exceedingly he is beholden to that great Wiſdom and Power which expanded him from the little *Stamen* and Clew in which he was roll'd, firſt to an imperfect Subſtance, and afterwards to ſuch a noble and well-contrived Body, without the leaſt Knowledge or Concurrence on his own part.

SECT. V. *It is unknown, whether the Earth or the Sun moves.*

IF now (paſſing by a great number of things that are ſtill unknown) we proceed in the laſt place to give a famous Inſtance of one more unknown thing, namely, whether the Sun or the Earth moves, and conſequently to which of them we owe the Days and Nights, and the Seaſons of the Year: I doubt not but it may appear very ſurpriſing to many, and eſpecially to thoſe who without having taken the pains, or had an occaſion experimentally to enquire into Aſtronomy themſelves, do found the whole Structure of Natural Philoſophy upon this or that Hypotheſis; tho' otherwiſe the greateſt Mathematicians are fully convinced, that altho' there has been perhaps no other thing examined into with more Pains, Charge and Application, in order to know the ſame with Certainty, yet nothing entirely poſitive can be advanced concerning it.

SECT. VI. *Such Ignorance proceeds, Firſt, from the Diſagreement of great Aſtronomers.*

NOW to ſatisfy every unprejudiced Perſon of the Truth of what we have aſſerted, we ſhall endeavour to prove it, *Firſt*, from the Diſagreement of the greateſt Inquirers into this matter. Accordingly we find among the Ancients, that *Philolaus* held one ſide of the Queſtion, and *Ptolemy* the other; and among the Moderns *Tycho Brahé* maintains, that the Earth ſtands ſtill, but *Kepler* that it moves, and both theſe were famous Aſtronomers. It may be, the Reader will be ſurpriſed that I have not mentioned the Great *Copernicus*; but the Reaſon why I have omitted him is, becauſe we find that he himſelf was convinced, that nothing could be certainly laid down concerning this matter in his Time, as we ſhall ſhew more fully by and by. Others again ſuppoſe the Diurnal Motion of the Earth about its own Axis but an Annual Motion of the Sun, who are therefore called *Semi-Tychonics*; and they likewiſe do thereby account for all the preſent known Phænomena, as well as *Copernicus* and *Tycho Brahé*.

To ſee this proved, we may conſult Dr. *Gregory*'s Aſtronomy, at the Eleventh Part of the Firſt Book, together with many more Authors, who have with great Skill and Judgment ſhewn the Laws and Directions of the Motions whereby each of theſe three Hypotheſes may be ſupported.

Since then theſe great Men, from whom only one might expect a Determination of theſe Diſagreements, ſince they who have inquired into the Matter with ſo much more Care and Application than others, do ſtill differ ſo much among themſelves

ſelves about the ſame, can any one believe that they would not long ſince have agreed in one and the ſame Opinion, if ever it had been fully and rightly proved? the rather, foraſmuch as we find that they do not make the leaſt Difficulty to depart from the Opinions of *Ptolemy*, concerning the Orbits of *Venus* and *Mercury* (which he ſuppoſes to revolve about the Earth) as ſoon as ever the Experiments and Obſervations made by Teleſcopes had taught them, that theſe Planets moved only about the Sun, and by no means about the Earth; wherefore as long as this Diſagreement laſts between the greateſt Mathematicians, we may be pretty ſure that no Body has been able to ſee a ſolid Foundation of Truth in the Proofs produced by others; and conſequently that other Arguments which only depend on the Obſervations of thoſe, have not hitherto been able to prove any thing certain thereof.

SECT. VIII. Secondly, *Becauſe great Aſtronomers do themſelves own that they are uncertain about this Matter.*

Secondly, This may likewiſe be inferr'd from hence, that the moſt famous and moſt skilful Aſtronomers, after having employed ſo much Pains in this Inquiry, do freely and honeſtly confeſs, that they are ſtill entirely uncertain, concerning the Motion or Reſt of the Earth; which Confeſſion is yet ſtronger for this Purpoſe, than their Diſagreement.

And to the end that this may not ſeem incredible to thoſe who have a higher Opinion of theſe Mathematicians, than they have of themſelves, we will quote ſome of 'em, to witneſs the Truth of what is here advanced: Thus I remember, that having had the Honour to diſcourſe with the great Mr. *Huygens* about other Matters, and asking him whether he could affirm any thing, with Certainty,

tainty, about the Earth's Motion; he was pleaſed to anſwer, *That it was his Opinion, that as long as we were upon this Earth, no body could be able fully to prove the ſame.*

Thus likewiſe we ſee Sir *Iſaac Newton*, tho' with Mr. *Huygens*, he commonly ſuppoſes the Earth to move, yet he mentions the Matter with great Caution, and without advancing any thing poſitively; See *Princip. Philoſ.* p. 375, of the ſecond Edition, where it being affirmed, among the Hypotheſes, that the *Centre of the World is at Reſt, and not moved*; this Reaſon is added, *this is allowed on of all Hands, whilſt at the ſame time ſome make the Earth, others the Sun, to be at Reſt in the Centre of the World.* We likewiſe find in the fourth *Phenomenon*, this Expreſſion; *Of the five Principal Planets, and* (*of the Sun about the Earth or*) *of the Earth about the Sun, the Times of the Revolution are*, &c. and in the fourth Propoſition of the ſaid third Book, towards the End, we ſee thſe Words, *This Calculation* (which is of ſome Moment) *is founded on the Hypotheſis of the Immobility of the Earth.*

And can any one ſpeak out more plainly hereupon, than the famous and ſo highly eſteemed Mathematician, *P. Herigonus*; who in his *Curſus Mathem. de Sphæra Mundi*, p. 53. uſes theſe poſitive Words, *That the Earth in the Centre of the Firmament, or, that it is moved or not moved, cannot be proved by any Mathematical Demonſtration.*

And that we may know that other great Men do likewiſe ſpeak doubtfully of the *Earth's Motion*, we need only read the laſt Lines in *p.* 273, of Dr. *Gregory*'s *Aſtronomy*; where ſpeaking of the *Parallax* of the fixed Stars with reſpect to the Earth's Way, he thus concludes, *For after this Manner they might put the Motion of the Earth out of doubt, which every one would own is well worth the while.* By which he ſhews how uncertain that Matter ſtill is.

The Opinion of Mr. *de la Hire*, in the Preface to his Aſtronomy, is likewiſe declared upon this Matter; that great Aſtronomer ſaying, *But after I had compoſed ſome Motions from the daily and yearly Motion of the Sun, or of the Earth*, &c. from whence it plainly appears, that he durſt by no means determine the Matter.

Thus we find in *the Memoirs of the French Academy*, 1707, p. 14. That Mr. *Varignon* having ſaid, that *Ricciolus* had given ſeveral Reaſons for the *Immobility* of the Earth, and that *de Angelis* had returned an Anſwer to it, he the ſaid Mr. *Varignon*, far from determining which of 'em was in the Right, contented himſelf with declaring only, that *he did not undertake to inquire into their Arguments*; but ſuggeſted another Difficulty, which ſeems to render the *Earth*'s *Motion* yet more uncertain.

If now down to this preſent Time, in which moſt of theſe things have been written, one only ſolid Proof, to determine whether the Earth moved or ſtood ſtill, had been known to theſe great Men; can it be ſuppoſed that Perſons of their Learning, moſt of whom form their Computations upon the Hypotheſis of a *moving Earth*, would have ſpoken ſo doubtfully and uncertainly thereof.

SECT. VIII. Thirdly, *Becauſe the* Parallax *from the* Annual Motion *is ſtill uncertain.*

Thirdly, It is true that Mr. *Flamſtead* is of Opinion, that he is able to prove, from his Obſervations, a *Parallax* of the fix'd Stars, and conſequently that the Earth moves; but with how little Certainty, may appear from the place that we lately quoted out of Dr. *Gregory*'s Aſtronomy, to which Mr. *Whiſton* has replied in Defence of Mr *Flamſtead*: But this whole Diſcovery ſeems to be but of little Uſe for this Purpoſe, chiefly from what we read of Mr. *Caſſini*, the younger, in the *Tranſactions of the* French *Academy for the Year 1696.* to which Mr. *Whiſton* anſwering in his *Prælect. Phyſic. Mathem.* p. 202. (as much as he ſeems inclined to maintain the Certainty of the Earth's Motion from the above-mention'd Obſervations, for nothing certain can be concluded upon any other Principle) does confeſs, *that Mr.* Flamſtead *does not argue right in every thing, as the* French *have lately obſerved; and that he often deduces the* Parallax *of the fix'd Stars from the Phenomena, that do by no means prove the ſame; which in ſo great an Aſtronomer as he was, appeared very ſtrange to him:* Concluding with the following Words, after he had ſaid ſomething which did not imply much Certainty; *but this muſt be left to the farther Diligence and Wiſdom of the Aſtronomers.* So that this Gentleman, who is otherwiſe wont to declare himſelf with very ſtrong Expreſſions againſt thoſe that maintain the Immobility of the Earth, does nevertheleſs in this Caſe, as it appears from his own Words, finally leave the matter undetermined.

Now how little Hopes remain to find a *Parallax* of the fix'd Stars, whereupon to build with any Certainty, may be ſeen by *Sect.* XI. of the 3d Book of Dr. *Gregory's Aſtronomy*, and from the *Coſmotheoros* of Mr. *Huygens*, p. 134, &c. ſo likewiſe Sir *Iſaac Newton* ſays, *Princip. Philoſ.* Lib. 3. Sect 14. *That the Stars have no remarkable* Parallax *proceeding from the Annual Motion of the Earth.*

SECT. IX. *Nothing can be inferr'd from the Expreſſions uſed by great Aſtronomers, about the Earth's Motion.*

Now tho' the greateſt Mathematicians of this Age are not aſhamed freely to own their Uncertainty, as to the *Motion* or *Reſt* of the *Earth*; yet there is another Sort of Philoſophers, who being but little skilled in Aſtronomy, or Mathematicks, do confidently and poſitively maintain, that *the Earth moves*; becauſe they cannot imagine that ſo many, and ſo great Men, ſhould in their Writings and Calculations, ſuppoſe the ſame, if they were not fully aſſured thereof.

Now to convince them, that the Mathematicians themſelves do not always give credit to their own Hypotheſes, there needs no more to be ſaid, but that it is ſufficient for Mathematicians that they can moſt conveniently deduce from thence the hitherto known Phenomena, without conſidering, in the leaſt, whether they be true or no: A great Proof thereof may be found in a certain kind of Preamble to the Book of the famous *Copernicus*, the whole of which were worthy to be tranſcribed by us, had it not been too large. It is there ſaid, that *it is not neceſſary that the Hypotheſes ſhould be even probable, and that it is enough if the Calculations may be thereby made to agree with the Experiments.* And afterwards, *and ſince various Hypotheſes are often adapted to one Motion, (as in the Courſe of the Sun an Excentricity and a Motion about the Center) an Aſtronomer may chuſe that which is moſt eaſily comprehended: A greater Probability may perhaps be required from a Philoſopher, yet neither of them can be able to diſcover any thing with Certainty, unleſs God reveals it to them.* Whereupon finally, theſe emphatical Words follow: *Let no Body, ſo far as it concerns an Hypotheſis, expect any thing certain from Aſtronomy; ſince it won't afford any thing like that, leaſt by admitting for Truth that which is dreſs'd up for other Purpoſes, he ſhould leave this Science with greater Folly than he engaged in it.* I don't know whether any one could more ſtrongly confirm what has been ſaid before; and I think that the foregoing Objections are ſufficiently anſwered hitherto, by referring our Readers to the Authors of theſe ſeveral Books.

Thus we find in the Text of *Copernicus* himſelf, *Lib.* I. *Cap.* X. *p.* 20. That this great Aſtronomer, inſtead of producing Reaſons to ſupport the Truth of his Hypotheſis, contents himſelf with ſaying, *Which I think we ought to admit more readily, than to puzzle and confound our Minds with an infinite Number of Circles.*

After the ſame manner ſays *S. Stevin*, in the 5th *Propoſition* of the *Celeſtial Appearances*, with reſpect to a moving Earth; *That it does not appear neceſſarily, that the Sun ſhould be in the Center of the fix'd Stars, but that it is allowed to be ſo for good Reaſons.* And would you know his Reaſons? they are the following: After having ſaid, that it may be ſuppoſed, but, according to his Opinion, not fully proved; he concludes thus: *But it is more convenient to allow the Sun to be in the Center of the World, becauſe other* Phenomena *may be more eaſily and rationally ſolv'd thereby.*

Thus we hear the famous *Kepler* ſpeaking in his *Epitom. Aſtronom*, p. 448, and again 673. *When theſe Cauſes are underſtood, tho' they be not believed, but only ſuppoſed, the Uſe thereof will be very eaſy.*

But the ſame is very plainly made out by *the Tranſactions of the Royal French Academy* 1709. where Mr. *Caſſini*, after having ſpoken of the Uſes, Properties and Advantages of old and new Hypotheſes with great Learning, (but without maintaining the Truth of any of 'em) deſcribes very curious Planetary Machines, all of which are founded upon the Suppoſition of the Earth's Immobility. For which reaſon likewiſe he places the ſame immoveably, in the middle of thoſe Ellipſes, which the Planets ſeem to revolve in, in the ſpace of ſeveral Years, with regard to the Earth itſelf; and he even marks the appearing Revolution of the Sun about the Earth with a prick'd Circle. Now every Body knows, that altho' this great Aſtronomer does here uſe the Hypotheſis of an immoveable Earth, yet he does by no means aſſert the Truth thereof; nay he ſometimes uſes a different one.

From all which it appears, that theſe ſo highly eſteemed Mathematicians do more conſider the Conveniency than the Truth of their Hypotheſes in very many Caſes. But ſince ſome do pay ſuch a blind Deference to their Science, that when they ſee an Hypotheſis uſed by Men of a great Name, they take it only upon their Credit; therefore to convince theſe Gentlemen likewiſe, that we don't ſpeak at random, when we affirm, that ſuch a Mathematician does for the foregoing Reaſons of conveniency advance an Hypotheſis, which is not only abſolutely falſe, but even allowed to be ſo by himſelf, we ſhall preſent our Reader with a few Examples thereof.

Thus the Mathematicians do ſuppoſe imaginary Lines and Circles for the Conſtruction of thoſe ſo uſeful Tables of Sines and Tangents, *&c.* and in thoſe of *Logarithms*, that all Numbers are the true ones; whereas among Hundreds of them, there be very few that are really ſo: For which Reaſon alſo, and that the Difference between true and falſe may be the leſs, their way is to uſe ſuch great Numbers.

So likewiſe Surveyors, or thoſe that meaſure Land, tho' they find ſome Lines to be a little crooked, and ſometimes go in and out in ſmall Angles, yet they take them for ſtrait ones; provided only that from the Suppoſition of ſuch a known Falſity a greater Convenience reſults, and the Difference be not very conſiderable.

Who does not know, that making the Degrees of Latitude larger and larger in *Navigation*, is nothing but a meer Fiction, and only that one may with more Conveniency make good the real Decreaſe of each Degree of *Longitude*, though ſuch uſeful and neceſſary Tables are calculated upon the ſame Foundation?

Though it be known to ſuch as underſtand *Optics*, that Spherical Glaſſes never collect the Rays into a Point, (excepting in one or two Caſes) as Glaſſes of ſome other Figures do: Yet how common a Thing is it in the making of Teleſcopes or Microſcopes, to ſuppoſe the ſame, contrary to Truth; and the Demonſtration of the *Practical* Part is founded thereupon, even by ſuch as know that this is a manifeſt Falſity in the *Theory*?

What is more common than to ſuppoſe in *Statics*, that two Plumets fall down in ſtrait Lines parallel to each other, whereas they would notwithſtanding both meet at the Centre of the Earth?

In like manner, and upon the ſame Foundations, 'tis ſuppoſed by *Gunners*, and even by thoſe famous Mathematicians that write upon the Art of throwing Bombs, that their Balls by the Force of the Powder, and their own Gravity, do deſcribe a Line, which they call a *Parabola*; whereas if they conſidered the Reſiſtance of the Air, and other Cauſes aforemention'd, they would know that the Properties thereof were very different.

In *Dialling*, we ſuppoſe the Center of the Earth, or rather of the Sun's Courſe, to be always at the Top of the Perpendicular Style (when the Shadow of it, as a *Nodus*, ſhews the Hour) whereſoever the Dial be plac'd upon the whole Earth, though every Body knows it to be contrary to the Truth.

Thus all the ancient and modern Aſtronomers have always taken it for a Foundation of their Calculations, that the true or apparent daily Motion of the Sun is in a Circle parallel or equally diſtant from the Equinoctial, notwithſtanding that this Line, by the intermixing of the Sun's or Earth's Annual Courſe, comes nearer to a *Screw* or *Spiral Line*, than a Circle, as is well known to the Aſtronomers.

After having ſhewn all this in ſo many Branches of the Mathematicks, I don't think that a more expreſs Demonſtration will be required, to make appear, that altho' ſome of the chiefeſt among the Aſtronomers do ſuppoſe either the Motion or Reſt of the Sun, and found their Calculations thereupon, yet this does not in the leaſt ſhake either the one Hypotheſis or the other: Since, provided the Miſtakes be not of too great Importance, they frequently make uſe of Hypotheſes for Convenience ſake, which they themſelves know to be falſe.

SECT. XI. *The Simplicity of an Hypotheſis is not always an Argument of its Truth.*

THERE is yet one Argument from whence ſome People do conclude a little too haſtily, that the Hypotheſis of the Earth's Motion is true; namely, becauſe it appears to them the *more ſimple* of all: And for farther Proof, ſay, that it is moſt becoming the Wiſdom of the great Creator, to bring about the greateſt Matters after the moſt *ſimple* Manner.

We ſhall not here enter into a large Diſcuſſion about the Weakneſs of this Characteriſtic; ſince no Body can know when a Machine is ſhewed to him, whether it be the moſt ſimple or no, unleſs all the Views and Ends of him that invented it were at the ſame time diſcloſed to him, which none will preſume to affirm concerning the Structure of the viſible World: For upon this Foundation, thoſe who maintain the Sun's or the Earth's Orbit to be Circular, contrary to experience, might juſtly alledge, that their Opinion had more Truth in it than that of thoſe who maintained the ſame to move in an Ellipſe or oval Figure: Foraſmuch as beyond all diſpute the Figure of a *Circle* is more ſimple than that of an *Ellipſis.*

But to come a little cloſer; let ſuch as maintain this, tell us what is the Reaſon why all Aſtronomers,

mers, at leaſt all that I know, and among whom there are likewiſe many that zealouſly contend for the Earth's moving, and the Sun's ſtanding ſtill, as *Copernicus* himſelf, and ſince him *Kepler*, *Lantsberg*, and in our time, the North-Hollander *Richard Rembrantſen van Nierop*; tho' all of them do in the *Theory*, or annual Courſe from Eaſt to Weſt, maintain the Hypotheſis of a moving Earth, (for as much as the Calculations are much more convenient according to them in this Caſe) yet in every thing that belongs to the *Sphærics*, or daily Revolution from Eaſt to Weſt, they are wont to make their Figures and Calculations directly contrary to their own Notions, upon the Foot of a moving Sun and a reſting Earth, tho' they commonly ſtart the greateſt Objections againſt this laſt.

Of what has been ſaid, there is no farther Proof neceſſary, ſince this is apparent to every Body in almoſt all Figures that are uſed by them to this Purpoſe; in which they are even wont to expreſs the *Parallels* in which the Sun daily moves, and to call them by that Name. It ſeems to me likewiſe to be particularly remarkable, that Mr. *Whiſton* himſelf, who is otherwiſe ſo great a Champion for a moving Earth, does tranſcribe the Demonſtration of the Manner after which Mr. *Caſſini* has ſo ingeniouſly obſerved the *Parallax* of the *Planets*, into his *Prælect. Aſtron.* p. 75, *&c.* with ſo great reſpect from the *Act. Lipſ.* 1685, almoſt in the Words of Mr. *Blanchini*; notwithſtanding that the ſame is formed upon the Hypotheſis of a fix'd Earth, and the daily Revolution of the fix'd Stars and Planets, ſhewing what he himſelf terms it, *The daily Revolution of* Mars *in a Circle*, and often uſing this Expreſſion, *That* Mars *and the* fix'd Stars *are moved and carried round about by the Diurnal Motion.*

We might produce many more Inſtances here, to ſhew how little Account is made of all Hypotheſes; but having dwelt ſo long upon this Matter already, we chooſe rather to refer our Reader to the Preface of Mr. *de la Hire's Aſtronomy*; there is likewiſe ſomething ſaid about the ſame in our *Introduction. Sect.* XVI.

SECT. XII. *A Concluſion from the Whole, that neither the Sun's nor the Earth's Motion has ever been rightly proved.*

NOW to come to a Concluſion from what has been hitherto ſaid of the Motion or Reſt of the Earth.

I. Since the greateſt Men do ſtill differ upon this Point, and no Body has yet been ever able to produce a fix'd and ſolid Proof of the Truth on one Side or the other. (*Sect.* VI.)

II. Since ſuch famous Mathematicians and principal Aſtronomers as *Huygens*, *Newton*, *la Hire*, *Varignon*, (to whom few will dare to compare themſelves in the Knowledge of Aſtronomy, without being thought very preſumptuous and conceited) and ſo many other have ingenuouſly confeſſed their uncertainty in this Matter, tho' they are of the moſt modern, ſome of them being ſtill alive, and all till lately; and conſequently have had the beſt Opportunities that can be yet procured of examining into every Thing that has been diſcovered concerning the ſame. (*Sect.* VIII.)

III. Since the hopes of finding out the *Parallax*, and diſtance of the fix'd Stars from the Earth, are very ſmall, by which otherwiſe the Matter might be determined after a good, if not the beſt manner. (*Sect.* IX.)

IV. Since we cannot find any Demonſtration of the Proof upon it, becauſe very learned Men have indifferently made uſe of the one or the other Hy-

Hypotheſis; foraſmuch as in almoſt all the Branches of Mathematicks, Hypotheſes are uſed not to ſhew how the Thing is really in it ſelf, but only in order to deduce from thence the known *Phænomena* with the greateſt Convenience, and with the leaſt ſenſible Difference; ſo that even Things that are known to be entirely diſagreeing with Truth, are frequently ſuppoſed, for the aforeſaid Reaſons, even by the greaſt Men that treat of Mathematical Matters. (*Sect.* X.)

V. And laſtly, ſince the ſame Mathematicians do one while make uſe of this Hypotheſis, another while of that, according to their Convenience in preſent Caſes, or for the eaſe of their Calculations, or for the better Conception thereof, or Deſcription of them by Figures in the moſt plain and ſimple manner. (*Sect.* XI.)

Let every Body conſider with himſelf, whether he can be perſwaded, that there will ever be diſcovered any ſolid or proper Proof, ſuch as may be ſufficient experimentally to convince Men, that the Motion or Reſt of this Globe of the Earth is demonſtrable, clearly and plainly, and to the Satisfaction of true Mathematicians: At leaſt if any one ſhould pretend to aſſert this, it would be the ſame thing as if he ſhould declare, that all thoſe great and learned Aſtronomers above-named, have been either ſo ignorant as not to be able, or ſo malicious as not to be willing to underſtand ſuch a Proof; which any Man who is juſt and reaſonable, muſt think to be the greateſt Abſurdity.

The End of the Third and laſt Volume.